EXHIBIT 8

Appendix A

John R. Black, Jr.

Department of Computer Science
430 UCB
University of Colorado
Boulder, CO 80309-0430 USA

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FAX: +1 303 492-2844
secretary: +1 303 492-7514

Email: jrblack@cs.colorado.edu
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Position

Assoc. Prof. Computer Science, University of Colorado at Boulder *7/08–present*

Research

Cryptography, Network Security, Computer Security.

Past Employment

SecureSet LLC *9/15–7/18*
Vice President of Education

University of Colorado at Boulder *7/02–7/08*
Assistant Professor of Computer Science.

University of Nevada, Reno *7/00–6/02*
Assistant Professor of Computer Science.

University of California, Davis *7/97–7/00*
Research Assistant

University of California, Davis *8/95–6/97*
Teaching Assistant

Ingres Corporation *6/88–4/94*
Senior Member of Technical Staff

Education

University of California, Davis *9/95–9/00*
Ph.D. in Computer Science.
Thesis: Message Authentication Codes.
Advisor: Phillip Rogaway.

California State University at Hayward *9/84–6/88*
B.S. in Computer Science and Mathematics, 1988.
Honors: Summa Cum Laude

Awards

NSF CAREER Award, 2002
Chancellor's Teaching Fellowship, UC Davis, 1998
Outstanding Teaching Assistant, UC Davis, 1998
Outstanding Teaching Assistant, UC Davis, 1997
A Check for $2.56 from Don Knuth, 1996

Appendix A

Journal Publications

1. P. Rogaway, M. Bellare and J. Black, "OCB: A Block-Cipher Mode of Operation for Efficient Authenticated Encryption." *ACM Transactions on Information and System Security (TISSEC)*, Volume 6, Issue 3, pp. 365–403, August, 2003.

2. J. Black, and P. Rogaway, "CBC MACs for Arbitrary Length Messages: The Three-Key Constructions." *Journal of Cryptology*, Volume 18, Number 2, pp. 111–132, Spring, 2005.

3. J. Black, "The Impossibility of Technology-Based DRM and a Modest Suggestion." *Journal of Telecommunications and High-Technology Law —JTHTL*, Volume 3, Number 2, pp. 387–396, Spring, 2005.

4. J. Black, M. Cochran and R. Gardner, "An Analysis of the Internet Chess Club." *IEEE Security and Privacy*, Volume 4, Number 1, pp. 46–52, January, 2006.

5. J. Black, M. Cochran and T. Shrimpton, "On the Impossibility of Highly-Efficient Blockcipher-Based Hash Functions." *Journal of Cryptology*, Volume 22, Number 3, pp. 311–329, Fall, 2009.

6. J. Black, P. Rogaway, T. Shrimpton, and M. Stam "An Analysis of the Blockcipher-Based Hash Functions from PGV." *Journal of Cryptology*, Volume 23, Number 4, pp. 519–545, Fall, 2010.

7. C. Wilks, M. Cline, E. Weiler, M. Diehkans, B. Craft, C. Martin, D. Murphy, H. Pierce, J. Black, D. Nelson, B. Litzinger, T. Hatton, L. Maltbie, M. Ainsworth, P. Allen, L. Rosewood, E. Mitchell, B. Smith, J. Warner, J. Groboske, H. Telc, D. Wilson, B. Sanford, H. Schmidt, D. Haussler, D. Maltbie "The Cancer Genomics Hub (CGHub): overcoming cancer through the power of torrential data." *Database*, Volume 2014, doi: 10.1093/database/bau093.

Book Chapters

1. J. Black, "Cryptography." Invited article for the Encyclopedia of Life Support Systems under the auspices of UNESCO. See `http://www.eolss.net`. 14 pages, March, 2004.

2. J. Black, "Authenticated Encryption." Invited article for the *Encyclopedia of Cryptography and Security*, Springer-Verlag. 12 pages. August, 2005.

Appendix A

Conference Publications (Refereed)

1. J. Black, C. Martel, and H. Qi, "Graph and Hashing Algorithms for Modern Architectures: Design and Performance." *Workshop on Algorithm Engineering — WAE '98*, Saarbrücken, Germany. Second Workshop on Algorithm Engineering, proceedings, pp. 37–48. Full version of this paper available at `theory.cs.ucdavis.edu`.

2. J. Black, S. Halevi, H. Krawczyk, T. Krovetz, and P. Rogaway, "UMAC: Fast and Secure Message Authentication." *Advances in Cryptology — CRYPTO '99*, Lecture Notes in Computer Science, Vol. 1666, Springer-Verlag, pp. 216–233, 1999. Full version and updated version of this paper available at `www.cs.ucdavis.edu/~rogaway/umac`.

3. J. Black and P. Rogaway, "CBC MACs for Arbitrary-Length Messages: The Three-Key Constructions." *Advances in Cryptology — CRYPTO 2000*, Lecture Notes in Computer Science, Vol. 1880, Springer-Verlag, pp. 197–215, 2000.

4. P. Rogaway, M. Bellare, J. Black and T. Krovetz, "OCB: A Block-Cipher Mode of Operation for Efficient Authenticated Encryption." *Eighth ACM Conference on Computer and Communications Security (CCS-8)*, ACM Press, pp. 196–205, 2001.

5. J. Black and P. Rogaway, "Enciphering Finite Sets of Arbitrary Size." *RSA Data Security Conference, Cryptographer's Track (RSA-CT)*, Lecture Notes in Computer Science, Vol. 2271, Springer-Verlag, pp. 114–130, 2002.

6. J. Black and P. Rogaway, "A Block-Cipher Mode of Operation for Parallelizable Message Authentication." *Advances in Cryptology — EUROCRYPT 2002*, Lecture Notes in Computer Science, Vol. 2332, Springer-Verlag, pp. 384–397, 2002.

7. J. Black and H. Urtubia, "Side-Channel Attacks on Symmetric Encryption Schemes: The Case for Authenticated Encryption." *USENIX Security Symposium — Security '02*. 10 pages, 2002.

8. J. Black, P. Rogaway, and T. Shrimpton, "Black-Box Analysis of the Block-Cipher-Based Hash-Function Constructions from PGV." *Advances in Cryptology — CRYPTO 2002*, Lecture Notes in Computer Science, Vol. 2442. 16 pages, 2002.

9. J. Black, P. Rogaway, and T. Shrimpton, "Encryption Scheme Security in the Presence of Key-Dependent Messages." *Selected Areas in Cryptography — SAC 2002*, Lecture Notes in Computer Science, Vol. 2595, 14 pages, 2002.

10. R. Motwani, J. Breidenbach and J. Black, "Collocated Dataglyphs for Large Message Storage and Retrieval." *Security, Steganography, and Watermarking of Multimedia Contents VI*, Society for Imaging Science and Technology (I&ST) jointly with International Society for Optical Engineering (SPIE), Vol. 5306, 19 pages, 2004.

11. J. Black, M. Cochran and T. Shrimpton, "On the Impossibility of Highly-Efficient Blockcipher-Based Hash Functions." *Advances in Cryptology — EUROCRYPT 2005*, Lecture Notes in Computer Science, Vol. 3494, Springer-Verlag, pp. 526–541, 2005.

12. J. Black, M. Cochran and R. Gardner, "Lessons Learned: A Security Analysis of the Internet Chess Club.", *Annual Computer Security Applications Conference — ACSAC 2005*, Tucson AZ, USA, pp. 220–228, 2005.

13. J. Black and M. Cochran and T. Highland, "A Study of the MD5 Attacks: Insights and Improvements", *Fast Software Encryption — FSE 2006*, Lecture Notes in Computer Science, Vol. 4047, Springer-Verlag, pp. 262–277, 2006.

Appendix A

Conference Publications (cont.)

14. J. Black, "The Ideal-Cipher Model, Revisited: An Uninstantiable Blockcipher-Based Hash Function.", *Fast Software Encryption — FSE 2006*, Lecture Notes in Computer Science, Vol. 4047, Springer-Verlag, pp. 328–340, 2006.

15. J. Black, "Compare-by-Hash: A Reasoned Analysis", *USENIX Annual Technical Conference — USENIX 2006*, 8 pages, 2006.

16. J. Black and M. Cochran, "MAC Reforgeability", *Fast Software Encryption — FSE 2009*, Lecture Notes in Computer Science, Vol. 5665, Springer-Verlag, pp. 345–362, 2009.

17. J.H. Huang, J. Black, and S. Mishra, "Security and Privacy in a Sensor-Based Search and Rescue System," *1st ICST/CREATE-NET International Conference on Ad Hoc Networks — ADHOCNETS 2009*, Vol. 28, Springer.

18. A. Sayler, D. Grunwald, J. Black, E. White, M. Monaco, "Supporting CS education via virtualization and packages: tools for successfully accommodating "bring-your-own-device" at scale," *SIGCSE 2014*, pp. 313-318, 2014.

Workshop Publications (Non-Refereed)

1. J. Black and P. Rogaway, "A Suggestion for Handling Arbitrary-Length Messages with the CBC MAC." *NIST Symmetric Key Block Cipher Modes of Operation Workshop—2000*, 4 pages, Sep 2000.

2. J. Black and P. Rogaway, "OCB: Proposal to NIST." *2nd NIST Symmetric Key Block Cipher Modes of Operation Workshop—2001*, 36 pages, Aug 2001.

3. J. Black and P. Rogaway, "PMAC: Proposal to NIST." *2nd NIST Symmetric Key Block Cipher Modes of Operation Workshop—2001*, 27 pages, Aug 2001.

Appendix A

Selected Talks

1. Data Structures for Fast Graph Algorithms. Presented at the 1997 UC Davis Workshop on Computing, Davis, USA, October 1997. (See Conference Publication #1.)

2. UMAC: Fast and Secure Message Authentication. Presented at CRYPTO '99, Santa Barbara, USA, August 1999. (See Conference Publication #2)

3. CBC MACs for Arbitrary-Length Messages: The Three-Key Constructions. Presented at CRYPTO 2000, Santa Barbara, USA, August 2000. (See Conference Publication #3)

4. A Suggestion for Handling Arbitrary-Length Messages with the CBC MAC. Presented at NIST Symmetric Key Block Cipher Modes of Operation Workshop—2000, October, 2000; also presented at the 2nd NIST Modes Workshop in Santa Barbara, USA, August 2001.

5. Enciphering Finite Sets of Arbitrary Size. Presented at RSA-CT '02, San Jose, USA, February 2002. (See Conference Publication #5)

6. A Block-Cipher Mode of Operation for Parallelizable Message Authentication. Presented at EUROCRYPT 2002, Amsterdam, The Netherlands, May 2002. (See Conference Publication #6)

7. Side-Channel Attacks on Symmetric Encryption Schemes. Presented at USENIX Security 2002, San Francisco, USA, August 2002. (See Conference Publication #7)

8. Practical Cryptography and Autonomic Web Computing. Invited talk at the 47th meeting of the IFIP Working Group 10.4. Rincon, Puerto Rico, January 2005.

9. On the Impossibility of Highly-Efficient Blockcipher-Based Hash Functions. Presented at EUROCRYPT 2005, Aarhus, Denmark, May 2005. (See Conference Publication #11)

10. The Ideal-Cipher Model, Revisited: An Uninstantiable Blockcipher-Based Hash Function. Presented at FSE 2006, Graz, Austria, March 2006. (See Conference Publication #14)

11. Compare-by-Hash: A Reasoned Analysis. Presented at USENIX Technical Conference 2007, Boston, MA, June 2006. (See Conference Publication #15)

Patents

1. T. McSheery, J. Black, S. Nollet, J. Johnson, and V. Jivan. Distributed-Processing Motion Tracking System for Tracking Individually Modulated Light Points. US Patent 6,324,296 B1. November 2001.

Funding

1. NCIIA E-Team Grant. "Entrepreneurship for Undergraduates." PI: John Black. Period: 2000-2001. Amount: $6,000.

2. University of Nevada Junior Faculty Research Grant. "Fast, Provably-Secure Cryptography." PI: John Black. Period: 2001-2002. Amount: $10,000.

3. NSF CAREER Award. "Highly-Optimized Provably-Secure Cryptography." PI: John Black. Period: 2002-2007. Amount: $469,925.

4. NSF NeTS Grant. "NeTS ProWIN: Topology And Routing With Steerable Antennas." PI: Dirk Grunwald. Co-PIs: John Black, Douglas Sicker. Period: 2005–2008. Amount: $745,215.

5. NSF Cybertrust Grant. "Cryptography for Constrained Environments." PI: John Black. Period: 2005–2008. Amount: $294,887.

Appendix A

Teaching History

ECS 122A — Design and Analysis of Algorithms (UC Davis). Co-taught once with Professor Rogaway; subsequently taught the course independently.
CMPSC 290G — Intro to Cryptoanalysis (UCSB).
CS 365 — Discrete Mathematics (UNR).
CS 425 — Software Engineering (UNR).
CS 426 — Senior Projects (UNR). Supervised 11 group projects in topics ranging from fingerprint recognition to audio editing to GUI design.
CS 432 — Computer Networks (UNR). Introduction to low-level networking concepts with an emphasis on network security.
CS 665 — Graduate Analysis of Algorithms (UNR). A typical algorithms course with emphasis on complexity theory.
CS 709 — Modern Cryptography (UNR). A graduate course introducing cryptography and visiting some of the research front.
CS 791G — Computer Network Security (UNR). A seminar course covering various topics related to network security.
CSCI 2270 — Data Structures (CU); Program design, Object orientation, Java, Linked lists, Arrays, Stacks and Queues, Hash tables, Trees, Balanced Binary Trees, Multi-core programming.
CSCI 3104 — Algorithms (CU); Divide-and-conquer, Greedy, Graph Algorithms, NP-Completeness, Quantum Algorithms.
CSCI 3753 — Operating Systems (CU); Scheduling, Virtual Memory, Filesystems, Multi-core systems, Pthreads, Kernel data structures, virtualization, Security.
CSCI 4830 — Network Security (CU); a new course developed to introduce basics of cryptography and network security. Covers SSL, PKI, DDOS attacks, wireless security, buffer overruns, and more.
CSCI 4900 — Solving Puzzles with Computers (CU); a one-unit undergraduate course describing some hard combinatorial puzzles and how computers can be used to attack them.
CSCI 5413 — Ethical Hacking (CU): Network security, nmap, netcat, Kali Linux, Buffer overruns, Format string vulnerabilities, Race Conditions, Web Security, SQL Injections, XSS, CSRF, Wireless.
CSCI 6268 — Foundations of Computer and Network Security (CU); an introductory course covering basic cryptography, cryptographic protocols, attacks, and principles, as well as core network security attack and defense.
CSCI 7000 — Cryptography Seminar (CU); A graduate course introducing basic cryptographic definitions and then making some forays to the research front.
CSCI 7000 — Cryptanalysis Seminar (CU); A graduate course introducing students to cryptanalysis. Differential and linear cryptanalysis, square attack, RSA basics, factoring, protocol errors, lattices, Coppersmith's algorithm.
CSCI 7000 — Quantum Computing (CU): Introduction to quantum circuits, number theory, Shor's Algorithm, Grover's Algorithm.

Graduate Students

Rakhi Motwani, M.S., Completed: Spring 2002.
Scott Fritzinger, M.S., Completed: Summer 2002.
Hector Urtubia, M.S., Completed: Spring 2003.
Hiba Fayoumi, M.S., Completed: Summer 2004.
Mary Hedges, M.S., Completed: Spring 2007.
Joesph Dunn, Ph.D., co-advisor with John Bennett, Completed: Summer 2007.
Martin Cochran, Ph.D., Completed: Spring 2008.
Jared Nishikawa, Ph.D., Completed: Spring 2016.

Appendix A

Undergraduate Students

Troy Trimble, University of California at San Diego. REU Student, Summer 2003.
Gagan Sekhon, California State University at Hayward. REU Student, Summer 2003.
Ryan Gardner, University of Colorado at Boulder. REU Student, Summer 2004.
Trevor Highland, University of Texas at Austin. REU Student, Summer 2005.

Appendix A

External Service

Secretary, International Association for Cryptologic Research, 2005–2007.
Program Committee, ACNS 2015.
Program Committee, CT-RSA 2015.
Program Committee, FSE 2014.
Program Committee, CT-RSA 2014.
Program Committee, CT-RSA 2013.
Program Committee, Eurocrypt 2012.
Program Committee, FSE 2011.
Program Committee, PKC 2011.
Program Committee, CANS 2010.
General Chair, CRYPTO 2009.
Program Committee, CRYPTO 2008.
Program Committee, ACNS 2008.
Program Committee, RSA-CT 2007.
Program Committee, ISC 2007.
Program Committee, ACNS 2007.
Program Committee, ACM CCS 2006.
Program Committee, CANS 2006.
Program Committee, ICISC 2006.
Program Committee, SECRYPT 2006.
Program Committee, ACSAC 2006.
Program Committee, CRYPTO 2005.
Program Committee, SAC 2005.
Program Committee, ICISC 2005.
Program Committee, CANS 2005.
Program Committee, IEEE SISW 2005.
Program Committee, CRYPTO 2004.
Program Committee, EUROCRYPT 2004.
Program Committee, RSA-CT 2003.
NSF CISE Panelist, 2001, 2003, 2005, 2006, 2007, 2009.
Referee for Journal of Cryptography, 1999-2006.
Referee for Software: Practice and Experience, 2005.
Referee for IEEE Communications Magazine, 2005.
Referee for IEEE Transactions on Circuits and Systems I, 2005.
Referee for IEEE Computer, 2005.
Referee for Journal of Computer Security, 2004.
Referee for IEEE Transactions on Information Theory, 2003.
Referee for IEEE Transactions on Computers, 2002.
Reviewer for CRYPTO 1999–2002, SODA 1998, SPAA 2002, Asiacrypt 2004, EUROCRYPT 2006.

Developed `CryptoStats` web site: an application which tracks publication rates by year, by author, by conference in the two main cryptography conferences. It was heavily used in my community (on average 240 hits per month), 2003-2009.

ACM Programming Contest problem composer, 2003–2007.
ACM Programming Contest site administrator, 2005.

Graduate Student Mixer organizer, CRYPTO 2005.

Appendix A

Internal Service

Chair, Computing Committee, 2010–2011, 2012–2015.
Chair, Space Committee, 2012–2015.
Liaison, Casey Feldman Foundation, 2010–2015.
Member, Departmental Executive Committee, 2003–2005, 2007–2009, 2013-2015.
Member, Executive Committee, Computer and Communications Security Center, 2003–2006.
Member, Departmental Search Committee, 2003–2006, 2012–2014.
Chair, Departmental Search Committee, 2008–2009.
Member, Graduate Committee, 2005–2006.
Developed departmental voting software, now used for all departmental votes and college votes.

Appendix A

Litigation Support C.V.

Prof. John R. Black

2019	
Firm:	DLA Piper
Attys:	Robert Buergi
Client:	Trend Micro; Defendant
Opposite:	CUPP Cybersecurity
Matter:	IP Litigation
Case No.:	3:18-cv-01251
Duties:	Reports on patent non-infringement; gave deposition
Outcome:	Ongoing

2020	
Firm:	Ropes and Gray
Attys:	Scott McKeown, Kyle Tsui, Victor Cheung, Carolyn Redding
Client:	Dolby; Plaintiff
Opposite:	Intertrust
Matter:	IP Litigation
Case No.:	3:19-cv-03371-EMC
Duties:	Expert Declaration in support of IPRs, gave deposition
Outcome:	All patents I worked on were invalidated

2020	
Firm:	Quinn Emanuel Urquhart & Sullivan; JWC Legal
Attys:	Sean Pak, Iman Lordgooie, Ron Hagiz, Jodie Cheng
Client:	ProofPoint; Plaintiff
Opposite:	Vade Secure
Matter:	Trade Secret and Copyright Litigation
Case No.:	3:19-cv-4238
Duties:	Technical consulting; code review, Expert Report on Trade Secrets; gave deposition, testified at trial
Outcome:	Verdict for Plaintiffs, Aug 2021

Appendix A

2020	
Firm:	Latham and Watkins
Attys:	Joseph Lee, Jeff Homrig
Client:	Facebook; Defendant
Opposite:	MasterObjects
Matter:	IP Litigation
Case No.:	3:21-CV-05428-WHA
Duties:	Expert reports on invalidity and non-infringement of patents; gave depositions
Outcome:	Facebook prevailed on summary judgement, Sep 2022

2020	
Firm:	Fish & Richardson
Attys:	Christian Chu, Jared Hartzman, Ruffin Cordell
Client:	LG, MediaTek, Realtek, HP; Defendants
Opposite:	Philips
Matter:	IP Litigation
Case No.:	ITC Docket No. 337-TA-3492
Duties:	Submitted Expert Report, gave deposition, testified at hearing
Outcome:	Verdict for Defendants, Oct 2021

2022	
Firm:	Kramer Levin
Attys:	Norm Simon, Samantha Alman
Client:	Meta Platforms
Opposite:	CTIA
Matter:	NAD Challenge and NARB Appeal
Case No.:	N/A
Duties:	Declaration on security of SMS versus End-to-End; testified before NAD Panel
Outcome:	Meta prevailed on all claims

2022	
Firm:	Ropes and Grey
Attys:	Andrew Radsch, Daniel Richards
Client:	Apple; Defendant
Opposite:	Aire Technology, Ltd.
Matter:	IP Litigation
Case No.:	6:21-cv-01101-ADA
Duties:	Filed declaration on 112 issues, gave deposition
Outcome:	Ongoing; currently stayed

Appendix A

2022	
Firm:	Faegre Drinker Biddle & Reath; Hogan Lovells
Attys:	Kirstin Stoll-DeBell (Faegre), Tej Singh (Hogan)
Client:	LG Electronics; Defendant
Opposite:	Hafeman
Matter:	IP Litigation
Case No.:	6:21-cv-00696-ADA
Duties:	Submitted Non-Infringement rpt; gave deposition, testified at trial
Outcome:	Jury verdict for defendants on non-infringement and invalidity

UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA

ANIBAL RODRIGUEZ, SAL CATALDO, JULIAN SANTIAGO, and SUSAN LYNN HARVEY, individually and on behalf of all other similarly situated, Plaintiffs, v. GOOGLE LLC, Defendant.	No. 3:20-cv-04688-RS

REBUTTAL EXPERT REPORT OF JOHN R. BLACK, PH.D.

May 31, 2023

Appendix B

Materials Considered

Appendix B
Materials Considered

Complaint and Legal Documents

- Anibal Rodriguez, Sal Cataldo, Julian Santiago, and Susan Lynn Harvey, individually and on behalf of all other similarly situated, v. Google, LLC, Fourth Amended Complaint, 3:20-cv-04688-RS, January 4, 2023.
- Declaration of Steve Ganem in Support of Joint Letter Brief Re: Google Preservation, Rodriguez v. Google, 3:20-CV-04688, Dkt. 193-1, p. 2-3 (N.D. Cal Dec. 12, 2021).

Bates-Stamped Documents

- GOOG-RDGZ-00024709.
- GOOG-RDGZ-00025637.
- GOOG-RDGZ-00033244.
- GOOG-RDGZ-00061172.
- GOOG-RDGZ-00067721.
- GOOG-RDGZ-0007167.
- GOOG-RDGZ-00071766.
- GOOG-RDGZ-00071767.
- GOOG-RDGZ-00089546.
- GOOG-RDGZ-00118124.
- GOOG-RDGZ-00130381.
- GOOG-RDGZ-00147439.
- GOOG-RDGZ-00151130.
- GOOG-RDGZ-00207669.
- GOOG-RDGZ-00205621.

Expert Reports

- Expert Rebuttal Report of Christopher R. Knittel, Ph.D., May 31, 2023, and materials cited therein.
- Expert Report of Jonathan E. Hochman, March 22, 2023, and materials cited therein.

Deposition

- Deposition Transcript of Sal Cataldo.
- Deposition Transcript of Steven Ganem.
- Deposition Transcript of J.K. Kearns.
- Deposition Transcript of Belinda Langner.
- Deposition Transcript of Anibal Rodriguez.
- Deposition Transcript of Chris Ruemmler.

Defendant Google LLC's Supplemental Responses and Objections to Plaintiffs' Interrogatories

- Defendant Google LLC's Supplemental Responses and Objections to Plaintiffs' Interrogatories, Set Four.
- Defendant Google LLC's Supplemental Responses and Objections to Plaintiffs' Interrogatories, Set Five.
- Defendant Google LLC's Supplemental Responses and Objections to Plaintiffs' Interrogatories, Set Seven.
- Defendant Google LLC's Supplemental Objections and Responses to Plaintiffs' Interrogatory, Set Six.
- Defendant Google LLC's Second Supplemental Responses and Objections to Plaintiffs' Interrogatories, Set Two.
- Defendant Google LLC's Second Supplemental Responses and Objections to Plaintiffs' Interrogatories, Set Three.
- Defendant Google LLC's Second Supplemental Responses and Objections to Plaintiffs' Interrogatories, Set Six.
- Defendant Google LLC's Fourth Supplemental Responses and Objections to Plaintiffs' Interrogatories, Set One.

Appendix B
Materials Considered

Publicly Available Documents

Google Websites

- "[GA4] Activate Google signals for Google Analytics 4 properties," Google Analytics Help, available at https://support.google.com/analytics/answer/9445345.
- "[GA4] Automatically Collected Events," Google Analytics Help, available at https://support.google.com/analytics/answer/9234069.
- "[GA4] Custom events," Google Analytics Help, available at https://support.google.com/analytics/answer/12229021.
- "[GA4] Data-deletion requests," Google Analytics Help, available at https://support.google.com/analytics/answer/9940393.
- "[GA4] Measure activity across platforms with User-ID," Google Analytics Help, available at https://support.google.com/analytics/answer/9213390.
- "[GA4] Predefined user dimensions," Google Analytics Help, available at https://support.google.com/analytics/answer/9268042.
- "[GA4] User explorer," Google Analytics Help, available at https://support.google.com/analytics/answer/9283607.
- "[GA4] Users properties," Google Analytics Help, available at https://support.google.com/analytics/answer/9355671.
- "About automated bidding," Google Ads Help, available at https://support.google.com/google-ads/answer/2979071.
- "About bidding in App campaigns," Google Ads Help, available at https://support.google.com/google-ads/answer/7100895.
- "About conversion events," Firebase Help, available at https://support.google.com/firebase/answer/6317518.
- "Ad request," Google AdMob Help, available at https://support.google.com/admob/answer/3544753.
- "Add Firebase to your Android project," Firebase, available at https://firebase.google.com/docs/android/setup.
- "Add Firebase to your Apple project," Firebase, available at https://firebase.google.com/docs/ios/setup.
- "AdMob policies and restrictions," Google AdMob Help, available at https://support.google.com/admob/answer/6128543.
- "Configure Analytics data collection and usage," Firebase, available at https://firebase.google.com/docs/analytics/configure-data-collection.
- "EU-focused data and privacy," Google Analytics Help, available at https://support.google.com/analytics/answer/12017362.
- "Find & Control your Web & App Activity," Google Account Help, available at https://support.google.com/accounts/answer/54068.
- "Firebase App Indexing User Data Policy," Firebase, available at https://firebase.google.com/policies/app-indexing.
- "Firebase App Indexing," Firebase, available at https://firebase.google.com/docs/app-indexing.
- "Firebase Solutions," Firebase, available at https://firebase.google.com/solutions.
- "Firebase," Firebase, available at https://firebase.google.com.
- "Google Account," Google, available at https://www.google.com/account/about/.
- "Google AdMob > Mobile Ads SDK (Android): Get Started," Google AdMob, available at https://developers.google.com/admob/android/quick-start.
- "Google AdMob > Mobile Ads SDK (iOS): Get Started," Google AdMob, available at https://developers.google.com/admob/ios/quick-start.
- "Google Analytics Terms of Service," Google Marketing Platform, available at https://marketingplatform.google.com/about/analytics/terms/us/.
- "Google Analytics," Firebase, available at https://firebase.google.com/docs/analytics.
- "Google Publisher Policies," Google Publisher Policies Help, available at https://support.google.com/publisherpolicies/answer/10502938.
- "Guidance for complying with the Identifying Users policy," Google AdSense Help, available at https://support.google.com/adsense/topic/6162392.
- "How Google uses location information," Google Privacy & Terms, available at https://policies.google.com/technologies/location-data.
- "How personalized ads work," My Ad Center Help, Google, available at https://support.google.com/My-Ad-Center-Help/answer/12155656.
- "Identifying users," Google Publisher Policies Help, available at https://support.google.com/publisherpolicies/answer/10436913.
- "Impressions," Google AdMob Help, available at https://support.google.com/admob/answer/3269069.
- "Measure screenviews," Firebase, available at https://firebase.google.com/docs/analytics/screenviews.
- "My Activity," Google My Activity, available at https://myactivity.google.com.
- "Personalized and non-personalized ads," Google AdMob Help, available at https://support.google.com/admob/answer/7676680.

Appendix B

Materials Considered

- "Privacy and Terms," Google, available at https://policies.google.com/privacy/key-terms.
- "Set up conversions from Firebase or App Attribution Partners for App campaigns for engagement," Google Ads Help, available at https://support.google.com/google-ads/answer/9260620.
- "Upload data use policy," Google Analytics Help, available at https://support.google.com/analytics/answer/2838984.
- "Use Firebase with Google AdMob," Firebase, available at https://firebase.google.com/docs/admob.
- "What is AdMob," Google AdMob, available at https://admob.google.com/home/resources/what-is-admob/.

Other Company Websites

- "2023 VPN Usage Statistics," Security.org, available at https://www.security.org/vpn/statistics/.
- "App Tracking Transparency," Apple, available at https://developer.apple.com/documentation/apptrackingtransparency.
- "Connect with the world's leading brands," AppsFlyer, available at https://www.appsflyer.com/solutions/partners/.
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UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA

ANIBAL RODRIGUEZ, SAL CATALDO, JULIAN SANTIAGO, and SUSAN LYNN HARVEY, individually and on behalf of all other similarly situated, Plaintiffs, v. GOOGLE LLC, Defendant.	No. 3:20-cv-04688-RS

REBUTTAL EXPERT REPORT OF JOHN R. BLACK, PH.D.

May 31, 2023

Appendix X1

Notes on Building, Running, Modifying and Testing Plaintiff's "WAA Toggle" Custom App

I. SOURCE CODE RECEIVED

1. Mr. Hochman's initial report contained only compiled versions of four apps: WAA-0 and WAA-1 for Android and WAA-0 and WAA-1 for iOS. Through attorneys for Google, I requested source code for these apps, which was provided to me. I have reviewed all of the disclosed source code for both the Android and iOS versions of the apps, which I discuss more fully below. Furthermore, I made some minor changes to the Android version of WAA-0 in order to test some of the behaviors in various ways, which I also discuss below. Before discussing either the code or my alterations, I first describe the steps I undertook to get the app running.

II. APP SETUP, BUILD AND CONFIGURATION

2. Mr. Hochman provided source code in a zip file, which I unzipped into a project folder called ***waa-toggle***. I then used Android Studio Flamingo, 2022.2.1 Patch 1 to open the project. I then used Android Studio to peruse the source code and understand how the app was constructed and how its various components functioned.

3. I then created a new Google account called analytics.cv.04688@gmail.com and used it to create a new Firebase analytics account. I also created a new yahoo account called johnblack.04688@yahoo.com. Using yahoo's developer portal, I created an app called "waa-toggle" and specified https://waa-toggle.firebaseapp.com/__/auth/handler as the callback URI for OAuth, enabling OpenID Connect Permissions for both Email and Profile. The Yahoo app config is shown below.

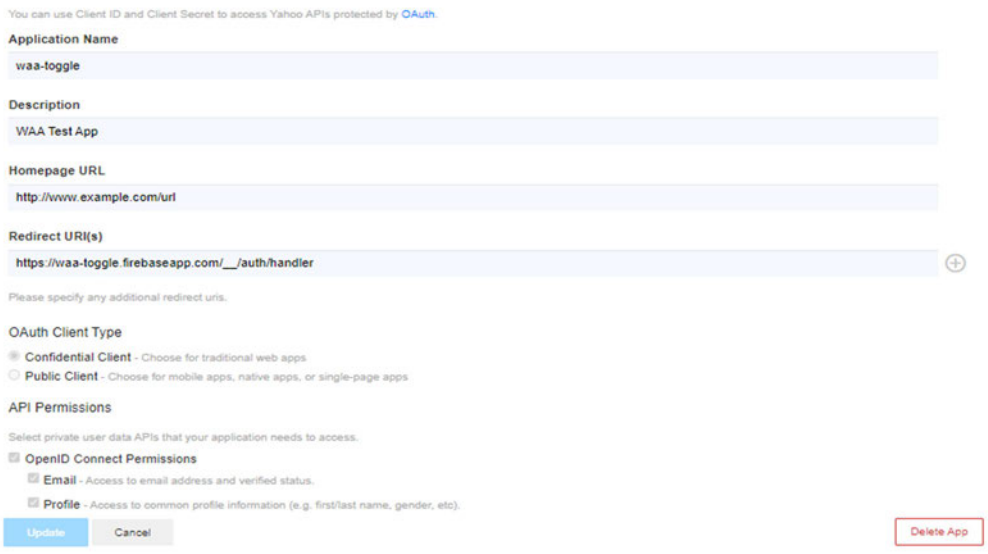


Figure 1. Yahoo App Config

4. I then copied the Client ID and Client Secret from the Yahoo developer page to the Firebase page for Yahoo sign-in and enabled Yahoo as a sign-in method. I also generated the SHA1 fingerprint for the self-signed *androiddebug* key using keytool and added that hash to Firebase settings for the waa-toggle app so that the app would be authenticated.

5. The steps above resulted in a new *google-services.json* (containing both the new analytics information as well as the authentication parameters).

6. I then paired my Google Pixel 6a phone to Android Studio. This phone is running Android 13, Baseband version g5123b-107485-221101-B-9242015.

7. Next, I built the waa-toggle app in WAA-0 mode with the new *google-services.json*, which deployed the app to my device. The Home Activity screen appeared as follows:

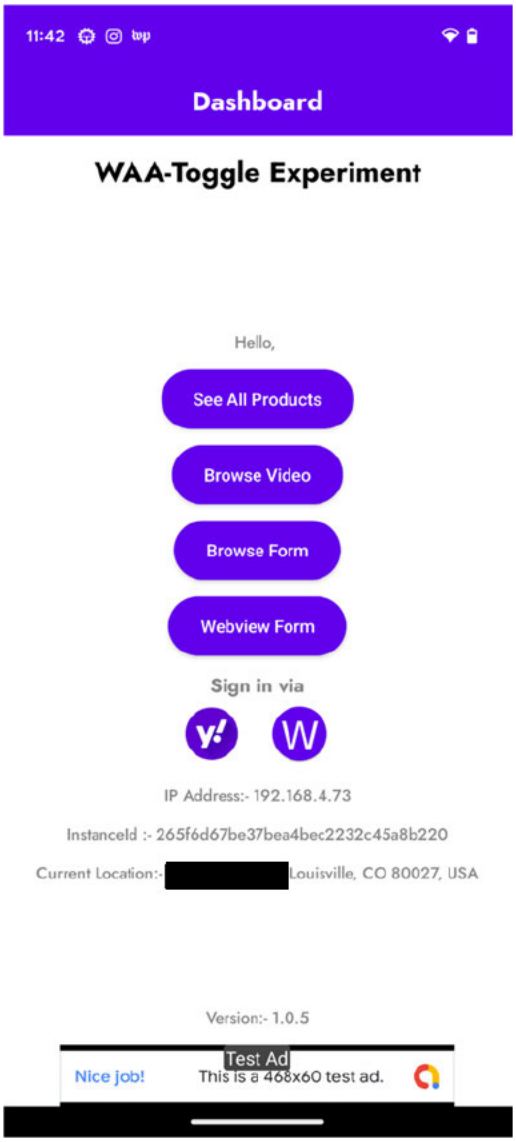


Figure 2: Home Activity Screen

III. APP OPERATION BEFORE MODIFICATION

A. User Login with Firebase Auth

8. In its initial state, no users are logged in. The app uses Firebase Authentication (a facility of Firebase that manages user sign-in and sign-out, distinct from the Firebase Analytics functionality discussed further below).

9. There are two options for user sign-in as shown in the screenshot above: either a Yahoo sign-in (accessed via the "Y!" button) or an app-specific sign-in (access via the "W" button)[1]. Pressing the "W" button prompts the user for username and password. The only valid users appear to be "Test1" and "Test2", based on my review of the source code:

Figure 3.

10. The password field can be anything (though it cannot be empty). This sets the username in an object called *waaPreference* to either Test1 or Test2, but the email in *waaPreference* is left unset.

11. Alternatively I can log into the waa-toggle app using my Yahoo account, johnblack.04688@yahoo.com by first pressing the Y! button which causes the app to use the Firebase Auth code to open a chrome tab and brings me to a Yahoo login screen. Here I enter my email (above) and my password. This causes Yahoo to return an authentication token and information that contains my Yahoo username ("John Black") as well as my email address back to Mr. Hochman's waa-toggle app. In this case, both my username and email address are stored in *waaPreference*.

12. To sum up: Mr. Hochman's app maintains an object specific to his app called "*waaPreference*" that tracks either username alone (for local logins) or username plus email (for Yahoo logins), among other things.

B. Event Logging with Firebase

13. Mr. Hochman's app uses Firebase to generate events both via GA4F and via custom events sent with Firebase Analytics *logEvent* feature. Mr. Hochman lists events "automatically created by Firebase" in his Appendix I-1[2]. Mr. Hochman lists the additional custom events (he calls them "exemplary programmed events") in Appendix I-2.[3] In other words, when a developer uses GA4F she can create two types of events: events that Firebase creates and logs automatically (such as "*screen_view*" when a user views a screen in the app) and she can create custom events (such as "login" which occurs when a user logs into the app). For automatic GA4F events, Firebase packages certain information

[1] Based on commented-out portions of the source code, there was a Google Sign-In button planned as well but it is not present in the app.

[2] *See also,* Hochman App'x I-1.

[3] *See also,* Hochman App'x I-2.

alongside the event type and sends it to Google servers. For custom events, the developer can package whatever she wishes alongside the event and send that to Google.

14. Google requires that developers agree to certain conditions in order to use Firebase[4]. In particular, developers agree not to send sensitive or personal information in a custom event. Google has no way to enforce this restriction using technology, since it would be difficult (or impossible) to differentiate between a harmless piece of data (like "character name" in a video game) versus important private data (like "actual name" of a real person). Google therefore requires the developer to respect the privacy of her users and treat any private information with care, including not sending it to Google for logging.

i. Mr. Hochman's apps violate this requirement.

15. Both the Android version and iOS version of Mr. Hochman's apps specifically send (at least) username and email address in each custom event via Firebase Analytics, in violation of Google's specific proscription against doing so. Mr. Hochman's Appendix I-2 shows that virtually every custom event generated by his app also sends (at least) the username and email with the event. The image below is taken from Hochman Appendix I-2 and shows the table in that appendix, omitting the last two entries (which do not contain username and email as parameters)[5]:

[4] "Terms of Service for Firebase Services," Google Firebase, available at https://firebase.google.com/terms

[5] *See also,* Hochman App'x I-2.

Event	Platform	Description	Parameters
Login	App	When user select Google account to loggedIn in the app	user_uid user_name user_email
sign_up	App	When user select Google account to loggedIn in the app (Only when selected Google email is not available in our firebase authentication)	user_uid user_name user_email
add_to_cart	App	When user clicks on "Add to cart" button in product detail screen	user_uid user_name user_email item_id item_name price
remove_from_cart	App	When user remove any product from cart	user_uid user_name user_email item_id item_name price
begin_checkout	App	When user clicks on "Pay Now" button in Cart screen	user_uid user_name user_email cart_items (productlist as string)
purchase	App	When user clicks on "Buy Now" button in product detail screen	user_uid user_name user_email item_id item_name price
payment_paid	App	When user clicks on "Pay Now" button in Credit Card Screen	user_uid user_name user_email item_id item_name price

Table 1.

16. As is apparent from the above, each custom event constructed by Mr. Hochman's app includes parameters deliberately included in the event, and these parameters have *user_name* and *user_email*, among others.

17. To contrast, the Firebase events that are automatically collected by the Firebase GA4F code are listed in Mr. Hochman's Appendix I-1 and none of these events includes any parameters that list username or email or any other item that suggests private information is being collected and sent to Google's servers. Hochman's Appendix I-1 is shown below[6]:

Event	Platform	Description	Parameters
first_open	App	the first time a user launches an app after installing or re-installing it	previous_gmp_app_id updated_with_analytics previous_first_open_count system_app system_app_update deferred_analytics_collection reset_analytics_cause engagement_time_msec
app_remove	App	when an application package is removed (uninstalled) from an Android device **Android only**	No parameters are collected
session_start	App & Web	when a user engages the app or website A session ID and session number are generated automatically with each session and associated with each event in the session.	No parameters are collected
app_clear_data	App	when the user resets/clears the app data, removing all settings and sign-in data **Android only**	No parameters are collected
app_exception	App	when the app crashes or throws an exception	fatal, timestamp, engagement_time_msec
screen_view	App	when a screen transition occurs and any of the following criteria are met: 1. No screen was previously set 2. The new screen name differs from the previous screen name 3. The new screen-class name differs from the previous screen-class name 4. The new screen id differs from the previous screen id	firebase_screen, firebase_screen_class, firebase_screen_id, firebase_previous_screen, firebase_previous_class, firebase_previous_id, engagement_time_msec
page_view	Web	each time the page loads or the browser history state is changed by the active site	page_location (page URL), page_referrer (previous page URL), engagement_time_msec
user_engagement	App & Web	when the app is in the foreground or webpage is in focus for at least one second.	engagement_time_msec
scroll	Web	the first time a user reaches the bottom of each page (i.e., when a 90% vertical depth becomes visible)	engagement_time_msec

Table 2.

6 *See also,* Hochman App'x I-2.

Event	Platform	Description	Parameters
form_start	Web	the first time a user interacts with a form in a session	form_id, form_name, form_destination
first_visit	App & Web	the first time a user visits a website or launches an Android instant app with Analytics enabled	No parameters are collected
form_submit	Web	when the user submits a form	form_id, form_name, form_destination, form_submit_text
video_progress	Web	when the video progresses past 10%, 25%, 50%, and 75% duration time For embedded YouTube videos that have JS API support enabled.	video_current_time, video_duration, video_percent, video_provider, video_title, video_url, visible (boolean)
first_open	App	the first time a user launches an app after installing or re-installing it This event is not triggered when a user downloads the app onto a device, but instead when he or she first uses it. To see raw download numbers, look in Google Play Developer Console or in iTunesConnect.	previous_gmp_app_id, updated_with_analytics, previous_first_open_count, system_app, system_app_update, deferred_analytics_collection, reset_analytics_cause, engagement_time_msec
video_start	Web	when the video starts playing For embedded YouTube videos that have JS API support enabled.	video_current_time, video_duration, video_percent, video_provider, video_title, video_url, visible (boolean)
video_complete	Web	when the video ends For embedded YouTube videos that have JS API support enabled.	video_current_time, video_duration, video_percent, video_provider, video_title, video_url, visible (boolean)
click	Web	each time a user clicks a link that leads away from the current domain	No parameters are collected

Table 3.

18. Therefore, in my opinion, the **only time private information is sent to Google's server** by Mr. Hochman's apps is when the app explicitly packages such information into a custom event and then sends it to Google's servers, in violation of Google's proscription forbidding such actions.

19. My opinion is further supported by an analysis of the relevant source code. In the Android code custom events are created by code in *waa_toggle/experiement/utils/GA4Ext.kt*:

```
fun Bundle.addCustomEvent(eventName: String) {
    WAAToggleApp.mFirebaseAnalytics.logEvent(eventName,  params: this)
}
```

Figure 4.

20. This function is called in various locations in the Android code, including each place where a "programmed event" as listed in Hochman Appendix I-2 (shown above) is generated. In every one of these custom events, the app bundles in the *waaPreference* object. For example, for the "login" event, the code builds a bundle and adds *waaPreference* before calling *addCustomEvent* to send the event and *waaPreference* to the Google servers.

```
    private fun addEventForLogin() {
        var bundle = Bundle()
        bundle = bundle.addUserParameter(waaPreference)
        bundle.addCustomEvent(FirebaseAnalytics.Event.LOGIN)
    }
```

Figure 5.

21. As explained above, *waaPreference* contains the username ("Test1" or "Test2" for local logins and the actual username if using Yahoo logins) along with email (empty for local logins, and the actual user email if using Yahoo logins). The code that extracts user ID, username, and user email from the authentication result object ("*authResult*") and puts it into *waaPreference* is in *waa_toggle/experiment/ui/activity/HomeActivity.kt*:

```
    waaPreference.setStringPref(
        USER_ID,
        authResult.user?.uid ?: ""
    )
    waaPreference.setStringPref(
        USER_NAME,
        authResult.user?.displayName ?: ""
    )
    waaPreference.setStringPref(
        USER_EMAIL,
        authResult.user?.email ?: ""
    )
```

Figure 6.

22. Then when *addUserParameter(waaPreference)* is called (shown above), the code adds these items into a bundle:

```
fun Bundle.addUserParameter(waaPreference: WAAPreference): Bundle {
    if (waaPreference.getStringPref(USER_ID).isNotEmpty())
        this.putString("user_uid", waaPreference.getStringPref(USER_ID))
    if (waaPreference.getStringPref(USER_NAME).isNotEmpty())
        this.putString("user_name", waaPreference.getStringPref(USER_NAME))
    if (waaPreference.getStringPref(USER_EMAIL).isNotEmpty())
        this.putString("user_email", waaPreference.getStringPref(USER_EMAIL))
    return this
}
```

Figure 7.

23. Every custom event listed in Hochman Appendix I-2, save the last two, calls this function to build a bundle with username and user email prior to then creating the custom event that is sent to Google's servers[7].

24. The Google Analytics website shows all events sent from Mr. Hochman's app, including the custom events and their associated parameters. For example, a login and *sign_up* event can both be observed on the *waa-toggle* Analytics page after I have logged into Mr. Hochman's app using my yahoo account:

---

7 *See also,* Hochman App'x I-2.

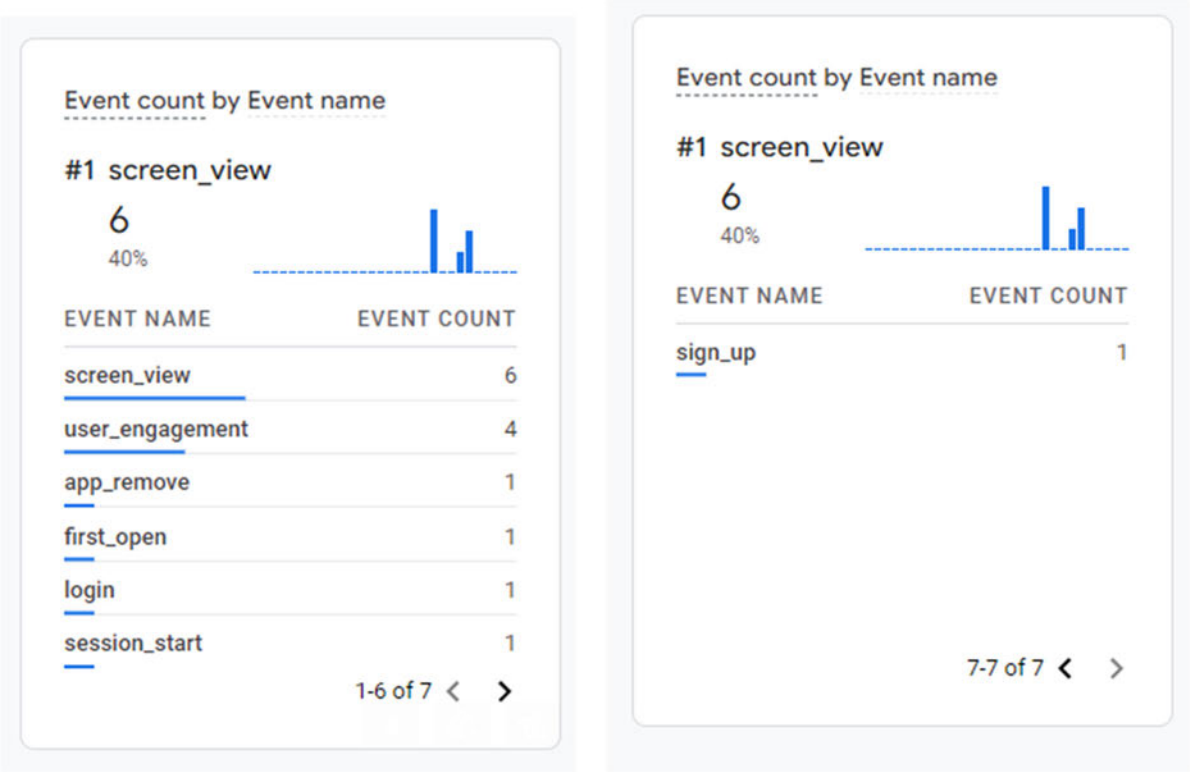


Figure 8. Google Analytics Website

25. Events generated by Firebase, such as *screen_view* or *first_open* do not include username or user email, but the custom events (login and *sign_up*) both do. For example, clicking on the *sign_up* event shows all parameters logged:

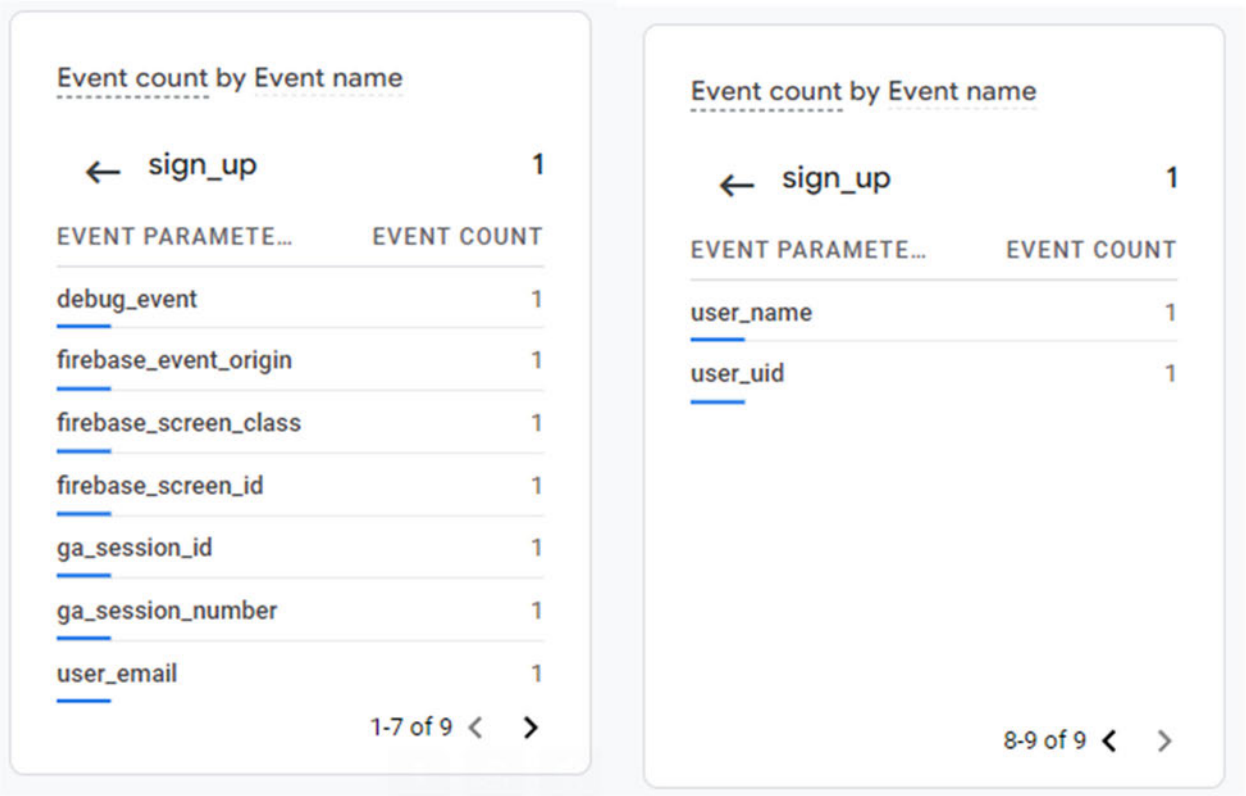


Figure 9. Google Analytics – "sign_up"

26. And clicking on *user_name* shows my actual name, sent by Mr. Hochman's app to Google's server:

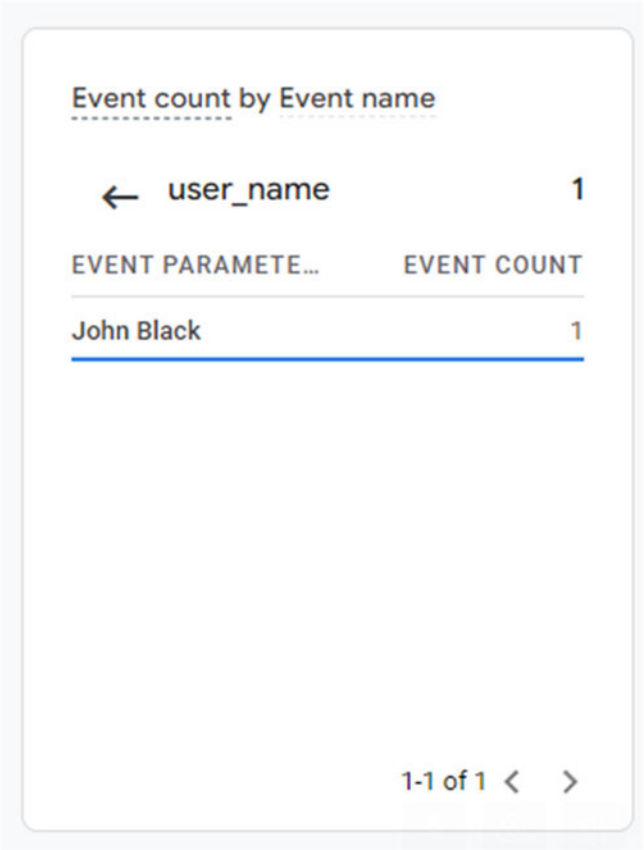


Figure 10. Google Analytics Website – "user_name"

27. Clicking on *user_email* shows my yahoo email address, again sent by Mr. Hochman's app to Google's server:

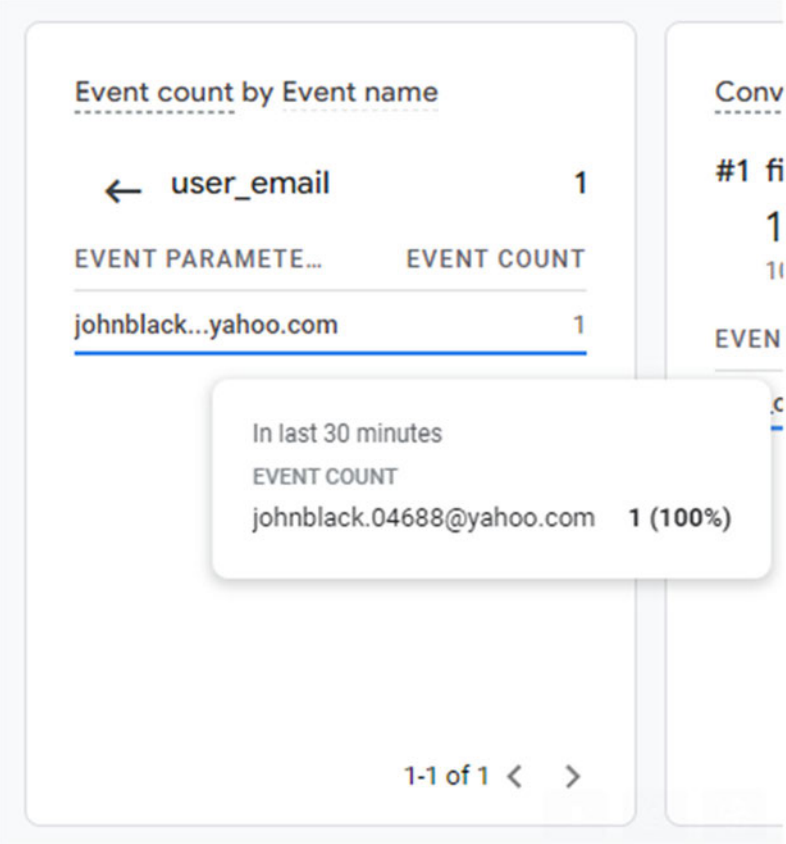


Figure 11. Google Analytics Website – "user_email"

28. The events automatically generated by Firebase do not have any such parameters; for example, *screen_view* has only the following parameters:

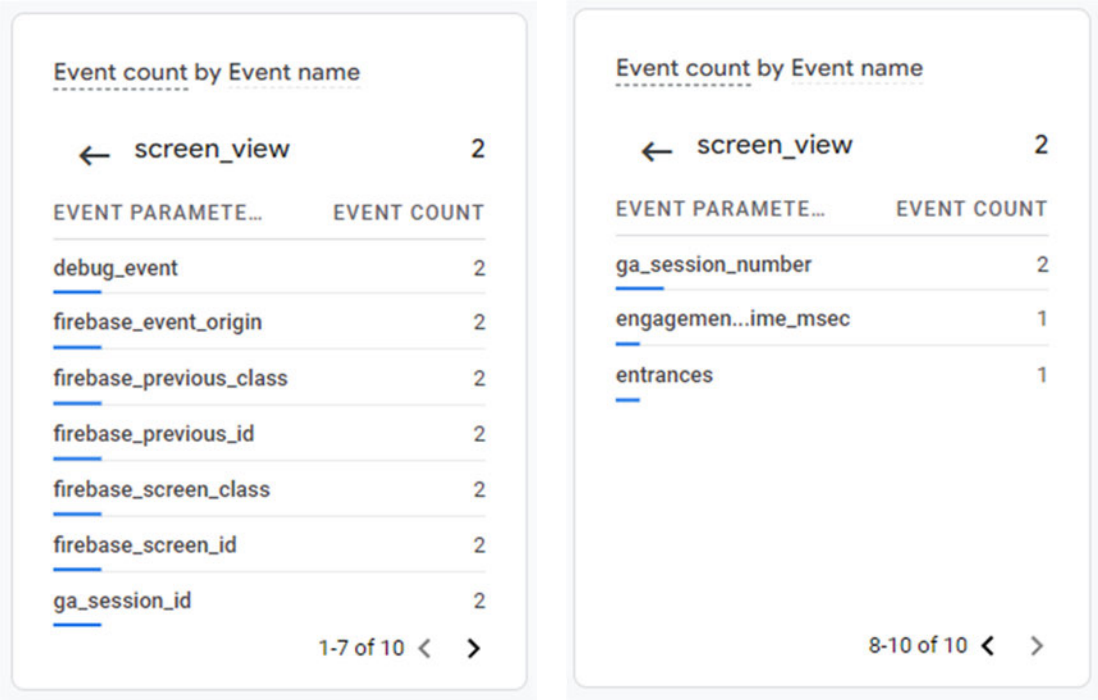


Figure 12. Google Analytics Website – Automatically Generated Events

29. Notably, no username or user email parameters are present here in this automatic Firebase event.

ii. Mr. Hochman's iOS apps also improperly send private information to Google.

30. The iOS code for Mr. Hochman's apps also sends the same private information in an explicitly created custom event. In the iOS source code, file *FirebaseEvents.swift*, custom events log (at least) user ID, username, and user email explicitly:

```
func logFirebaseEvents(eventName: String, product: Product) {

    if let user = User.shared {
        Analytics.logEvent(eventName, parameters: ["user_uid": user.userID,"user_name":user.name,"user_email":
```

Figure 13.

```
func firebaseAuthEvent(evenName:String) {

    if let user = User.shared {
        Analytics.logEvent(evenName, parameters: ["user_uid": user.userID,"user_name":user.name,"user_email": user.email])
    }
}
```

Figure 14.

```
func logFirebaseEventCheckout(eventName: String, cartList: String) {
    if let user = User.shared {
        Analytics.logEvent(eventName, parameters: ["user_uid": user.userID,"user_name":user.name,"user_email": user.email,
```

Figure 15.

IV. MODIFICATIONS TO MR. HOCHMAN'S ANDROID APP

As stated above, it is my opinion that private information such as username and user email are logged by Google only when a misbehaving app explicitly sends such information in a custom Firebase event. In order to confirm this, I modified Mr. Hochman's Android app.

UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA

ANIBAL RODRIGUEZ, SAL CATALDO, JULIAN SANTIAGO, and SUSAN LYNN HARVEY, individually and on behalf of all other similarly situated, Plaintiffs, v. GOOGLE LLC, Defendant.	No. 3:20-cv-04688-RS

REBUTTAL EXPERT REPORT OF JOHN R. BLACK, PH.D.

May 31, 2023

Appendix X2

Analysis of Baseview Data Production

1. Mr. Hochman analyzes two productions from Google (GOOG-RDGZ-00071766) and (GOOG-RDGZ-00071767) both containing baseview data pulled for the named plaintiffs using ADIDs from October 16 2021 to December 19 2021. Mr. Hochman's analysis appears in his report at 190-194 and his Appendix B-1 and B-2 (Excel spreadsheets), and is further reprised, in part, in his Appendix K.

2. In his main report, Mr. Hochman opined that "Google collects and saves WAA-off and sWAA-off data with identifiers that tie the data to a person, including name, e-mail, phone number, and Google identifiers."[1] I have reviewed the Google productions Mr. Hochman cites and I saw the information of the type he mentions in certain parts of those logs. To the extent Mr. Hochman opines that Google itself is somehow responsible for generating and sending those data to its servers, I disagree with that. In every case the appearance of a person's name, e-mail, phone number or any other identifier that could be used to identify an individual user is caused by an app written by a non-Google developer in a manner that violates the Google TOU that **expressly forbid** sending such data to its servers. For example, under the heading "Data collection" Google states the following:

> "While these identifiers provide information about user behavior, Google prohibits customers from sending Personally Identifiable Information to Google Analytics."[2]

3. My analysis below explains how I determined that certain non-Google apps caused the personal information Mr. Hochman identified to find its way into Google's baseview logs, in violation of this policy.

A. Baseview Data Productions, GOOG-RDGZ-00071766 and GOOG-RDGZ-00071767

4. I will refer to these files as the 766 and 767 productions, respectively.

5. The 766 production is a CSV (comma separated values) text file roughly 2.7GB in size containing 123,302 rows (excluding the header row). The 767 production is a JSON (javascript object notation) text file roughly 2.6GB in size, also containing 123,302 rows. As Mr. Hochman states, the data contained in these logs was extracted based on the submitted ADIDs for the named plaintiffs' phones, and contain log entries from October 16, 2021, to December 19, 2021.

---

[1] Hochman Report, ¶ 190.

[2] "Safeguarding Your Data," Google Support, available at https://support.google.com/analytics/answer/6004245?hl=en.

6. In each case when such information was found by Mr. Hochman (or by me), it was put there by an app authored by a non-Google entity via custom event parameters that permit developers to send custom information to their analytics account held by Google. Again, this violates Google's proscription forbidding this, but nonetheless there are examples where developers do so. (Indeed, Mr. Hochman's own custom apps submitted in this lawsuit also violate this policy and send personal information to the Google servers, as I explain in a separate section of my Report.)

B. Inserting Custom Information into an Event

7. Google allows app developers to insert custom information in analytics data in three primary ways: first, a developer can create a *user_parameter* which will be included with various automatic Firebase or GMA events; second, a developer can create custom events with *event_params* containing custom parameters; and third, custom information can be included as custom metrics and dimensions.

8. For *user_properties*, Google has certain rules: there are some reserved naming prefixes and there is a limit of 25 developer-supplied *user_properties*.[3] And, of course, Google dictates that developers include only information that is permissible under Google's policies.

9. A custom event is created in Firebase via *logEvent()* and is sometimes called a "Log Event."[4] Custom events can have *event_params* which are, again, custom pieces of information the developer wishes to store in their Google analytics account so that it can be used by the developer for analytics purposes. Once again, Google forbids the inclusion of personal information in *event_params*. (It is this *event_params* mechanism that Mr. Hochman used to send personal information to Google with his custom apps.)

10. Finally, custom dimensions can be added by a developer and can include information of the developer's choosing; Google includes various "dimensions" as part of its analytics framework but also permits custom information as well, which are sent by the developer[5].

C. Information in Baseview Logs Related to Anibal ("Pete") Rodriguez's Device

11. In his report, Mr. Hochman discusses the personal information for Plaintiff Anibal ("Pete") Rodriguez and shows a table with highlights where he found Mr. Rodriguez's name, phone

---

[3] "User Properties," Google Developers, available at https://developers.google.com/analytics/devguides/collection/protocol/ga4/user-properties?client_type=firebase.

[4] "Log Events in Your Android App," Google Firebase, available at https://firebase.google.com/docs/analytics/events?platform=android.

[5] "Custom Dimensions and Metrics," Google Analytics Help, available at https://support.google.com/analytics/answer/2709828.

number, email address and other information in the 766 and 767 productions. As I stated above, these entries are due to apps that Mr. Rodriguez had installed and was using on his Android phone at the time. Based on Mr. Rodriguez's ADID, I determined that 53,167 log entries out of the 123,302 total entries in the log were from Mr. Rodriguez[6].

12. According to my analysis, Mr. Rodriguez's information appears in the baseview logs with the frequencies shown in the table below:

Information Type	Value	No. of Occurrences	% of Total Rows with ADID
Name	Pete Rodriguez	20	0.04%
Email	[redacted]	413	0.78%
Phone	[redacted]	6	0.01%

13. Mr. Hochman also highlights other information he found related to Mr. Rodriguez's use of his phone, but none of these constitutes personal information of Mr. Rodriguez. For example, the model of Mr. Rodriguez's phone (a SM-G991U), the operating system (Android 11), the language setting (English), etc., are common to thousands or millions of people and in no way could be used to identify Mr. Rodriguez. The *app_instance_id* and *firebase_app_id* are unique, but are not public values that could be linked to Mr. Rodriguez, and Mr. Hochman does not opine that they are linked to his identity internally at Google, nor did I see any evidence that they are. And finally, the latitude and longitude values ([redacted] in Mr. Hochman's table) might be considered personal information if they were the precise coordinates locating Mr. Rodriguez at the time the record was created, but Google does not use the GPS feature of a device to obtain an exact latitude and longitude (indeed, many laptops and tablets do not even have GPS modules). Instead, Google uses the device's IP address[7] to guess at the city the user is in, and then sets latitude/longitude to the city center[8]. For example, in Mr. Hochman's example, the city is "Houston" (based on Mr. Rodriguez's IP address at the time), and the coordinates ([redacted]) point to the center of Downtown Houston.

---

[6] Some of the other entries may also have been due to Mr. Rodriguez but omitted his ADID. When looking for personal information I consider all 123,302 entries in the baseview log.

[7] An IP address is often a poor indicator of a person's geographical location, especially given the ubiquity of VPNs.

[8] "Geo - Dimensions & Metrics Reference," Google Analytics Real Time Reporting API, available at https://developers.google.com/analytics/devguides/reporting/realtime/dimsmets/geonetwork.

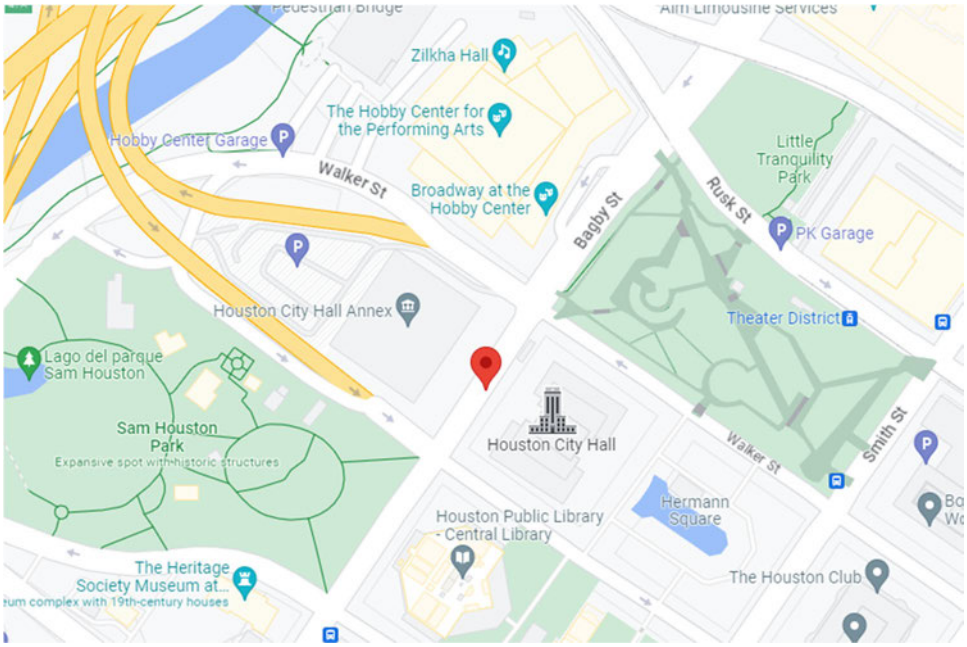


Figure 1. Coordinates on Google Maps

14. With respect to the three instances of personal information listed in the table above, I looked specifically at the log entries and found that in every case, the listed items containing Mr. Rodriguez's personal information were found either in a *user_properties* entry or in an *event_parameters* entry or in a custom dimension entry.

15. In the 20 cases where Mr. Rodriguez's first and last name appeared in a log entry, 5 of those were from an app called "Career Karma" (com.careerkarma.chat.Android) that set *user_properties* to contain *first_name* and *last_name*. In the remaining 15 instances where his name appeared, the app was the popular game Uno (com.matteljv.uno.Android).

16. In the case of Career Karma, Mr. Rodriguez's name appeared as a *user_properties* entry in all 5 cases; in fact, *user_properties* contain not only Mr. Rodriguez's name but also the name of his coach:

```
"user_properties":
[
```

Snippet 1.[9]

[9] All snippets are screenshots of production dataset GOOG-RDGZ-00071767.

```
{
    "key": "coachName",
    "value":
    {
        "value":
        {
            "string_value": "Nigel",
            "original_value_type": 1
        },
        "set_timestamp_usec": "1632147259601000"
    }
},
```


Snippet 2.

17. Also listed as *user_properties* were the various pieces of personal information in the table above.


```
{
    "key": "email",
    "value":
    {
        "value":
        {
            "string_value": "[redacted]",
            "original_value_type": 1
        },
        "set_timestamp_usec": "1632147259601000"
    }
},
```


Snippet 3.


```
{
    "key": "firstName",
    "value":
    {
        "value":
        {
            "string_value": "Pete",
            "original_value_type": 1
        },
        "set_timestamp_usec": "1632147259601000"
    }
},
```


Snippet 4.

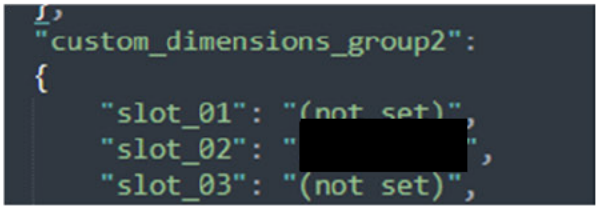
```
{
    "key": "lastName",
    "value":
    {
        "value":
        {
            "string_value": "Rodriguez ",
            "original_value_type": 1
        },
        "set_timestamp_usec": "1632147259601000"
    }
},
```


Snippet 5.

```
{
    "key": "phone",
    "value":
    {
        "value":
        {
            "string_value": "+[redacted]",
            "original_value_type": 1
        },
        "set_timestamp_usec": "1632147259601000"
    }
},
```


Snippet 6.

18. The above accounts for 5 of the 20 occurrences of Mr. Rodriguez's name, and 5 of 6 occurrences of his phone number. The remaining inclusion of his phone number was via a custom dimension sent by an app called Clipboard Health (health.clipboard.worker.Android):

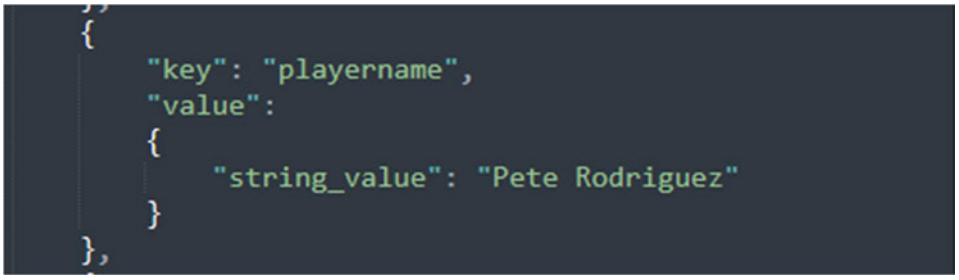


```
"custom_dimensions_group2":
{
    "slot_01": "(not set)",
    "slot_02": "[redacted]",
    "slot_03": "(not set)",
```


Snippet 7.

19. The remaining 15 instances of Mr. Rodriguez's name appeared in entries created by the Uno app (com.matteljv.uno.Android). In this case, name was sent to Google as player name:

…



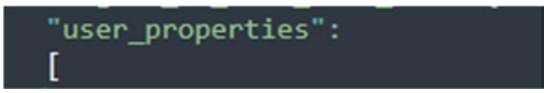
Snippet 8.

20. Finally, for the 413 instances of Mr. Rodriguez's email address, the offending apps that sent email addresses were as follows:

App that sent email address	No. Entries in Baseview Log
Steady! (com.steady.steadyapp)	335
JobGet (com.jobget.Android)	70
Career Karma (com.careerkarma.chat)	5
GigWalk (com.gigwalk.Android)	3

21. As described above, the 5 *user_properties* entries for Career Karma contained Mr. Rodriguez's email address alongside his other personal information.

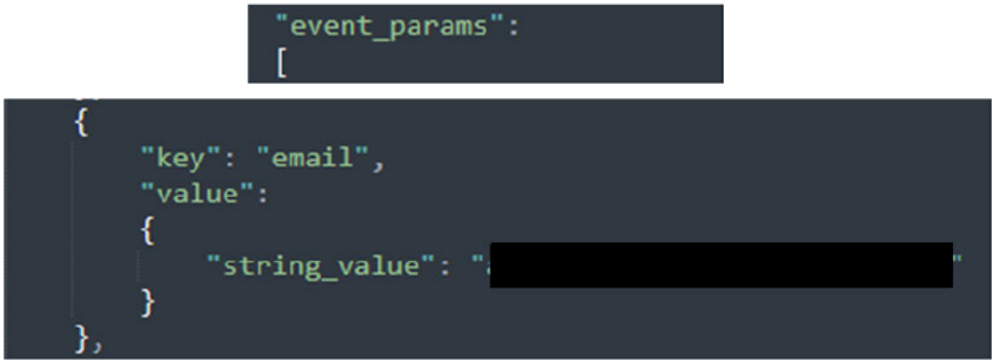
22. The Steady app page claims that it helps its users manage their financial status by giving advice on income and directing them to emergency cash funding sources. It includes Mr. Rodriguez's email address in *user_properties*:



...

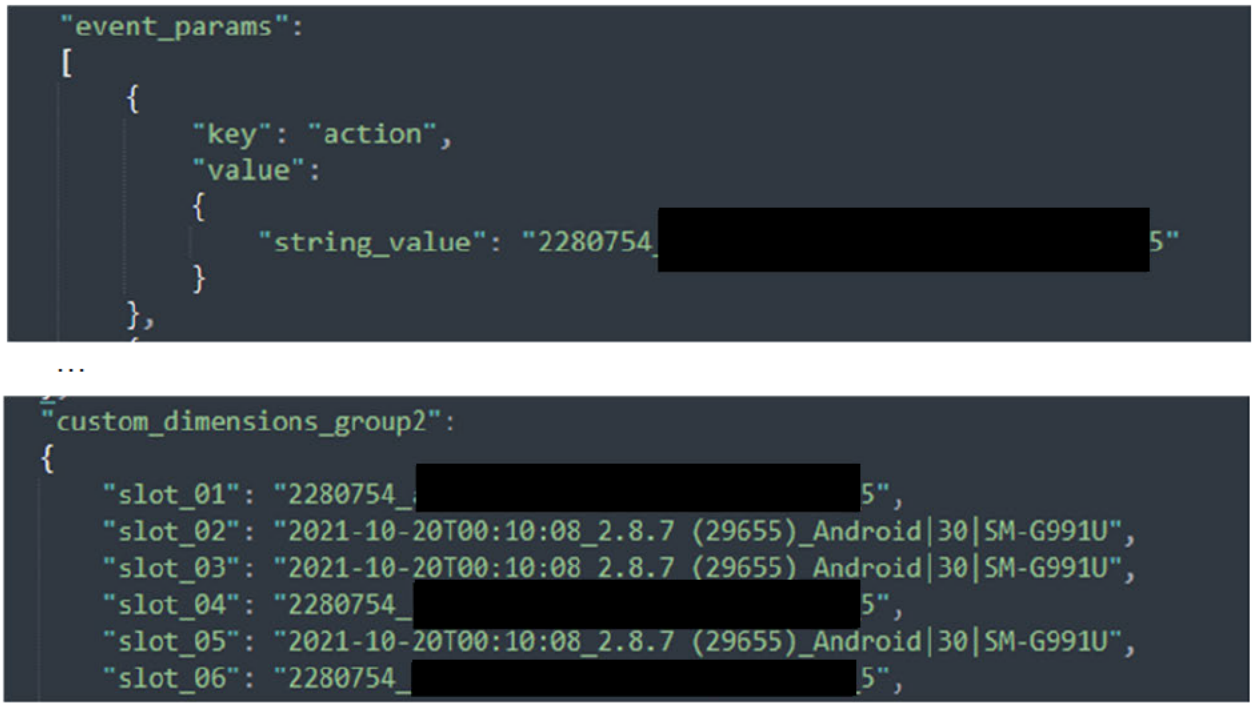
Snippet 9.

23. The JobGet app helps users find jobs quickly, stating "Get a job in 24 hours! JobGet is the fastest way to find jobs near you and get hired" on its Google Play app page. JobGet sends custom events to Google, and includes email address as an *event_params* entry:



Snippet 10.

24. Finally, Gigwalk is an app helping people earn extra money; its Google Play app page states: "Gigwalk is changing the future of work: earn money when and where you want to, starting today!" Gigwalk uses an annotated form of email address and sends it to Google both as *event_params* and in custom dimensions:



Snippet 11.

25. The above accounts for all instances of name, phone number or email of Mr. Rodriguez being sent to Google's analytics servers and reflected in the baseview productions made to plaintiffs. As demonstrated above, in every instance a misbehaving app used *user_properties*, *event_params* or *custom_dimensions* to send personal information to Google despite Google's expressly stated policy forbidding this.

26. Note that the apps listed above are a small fraction of all apps listed in the baseview production: limiting to baseview records with Mr. Rodriguez's ADID, there are 148 different apps listed. The most populous, by far, is OfferUp (a buying and selling app) with 22,252 entries, then Uno with 5,962 entries, followed by Call of Duty (a first-person shooter game) with 3,845 entries, then Google Maps with 1,742 entries, etc. Of these 148 different apps used by Mr. Rodriguez and contained in the baseview log, the 6 listed above sent an item of personal information (and only in some of their log entries), and the rest did not.

27. For each of the apps mentioned above, the app's Google Play app page includes a section regarding Data Privacy, and the details reveal that each app states that personal information is, in fact, collected by the app. In some cases, the app states that personal information is collected for purposes of "analytics." Although this disclosure does not grant a developer permission to violate Google's policies regarding privacy of user data, it is important to note

that the users themselves have apparently consented to the collection of their personal information for analytics purposes.

28. As an example of one of the apps in question, I examined Career Karma a bit more closely including its disclosures regarding Data Privacy. The other apps have similar disclosures.

D. Career Karma

29. Career Karma's app description page in the Google Play Store states that it is a "community of peers, mentors and coaches that will help you land a dream career in Tech." This app was not authored by Google and is not a Google product.

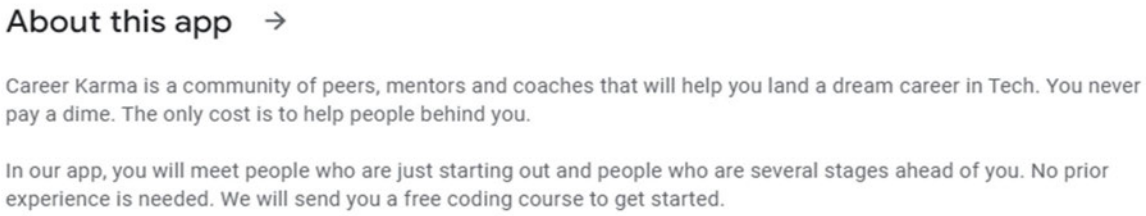


Figure 2. Career Karma App Description screenshot from Google Play page[10]

30. The same page also contains a section regarding Data Safety, and clicking on "See Details" displays the Career Karma Data Safety page which contains the following:

[10] "Career Karma," Google Play, available at https://play.google.com/store/apps/details?id=com.careerkarma.chat.

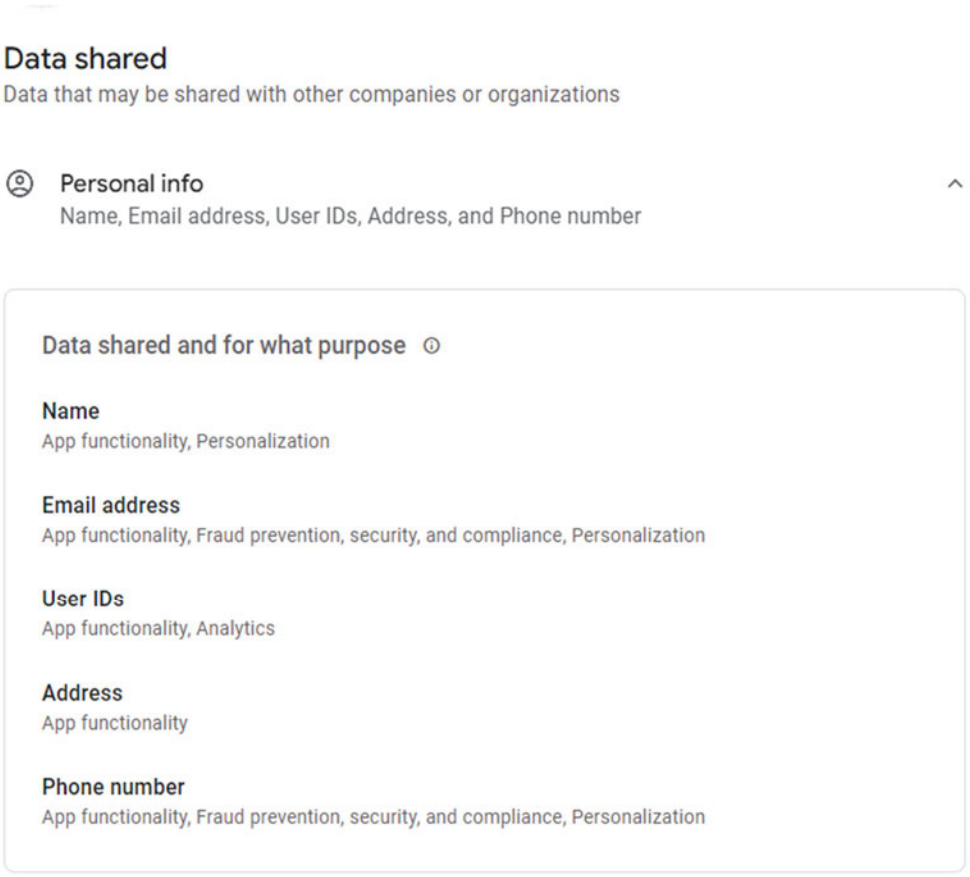


Figure 3. Screenshot from Career Karma's Data Privacy page[11]

31. It would appear that anyone using this app should be aware (and must find acceptable) the possibility that this app will share various personal data (including name, email, phone number, etc) with "other companies and organizations."

32. The Career Karma Data Privacy page also has a "Data Collected" section which also states that the app may collect personal information similar to the list above. It also notes that "App Activity" includes data collection for analytics and personalization:

[11] "Career Karma," Google Play, available at https://play.google.com/store/apps/datasafety?id=com.careerkarma.chat.

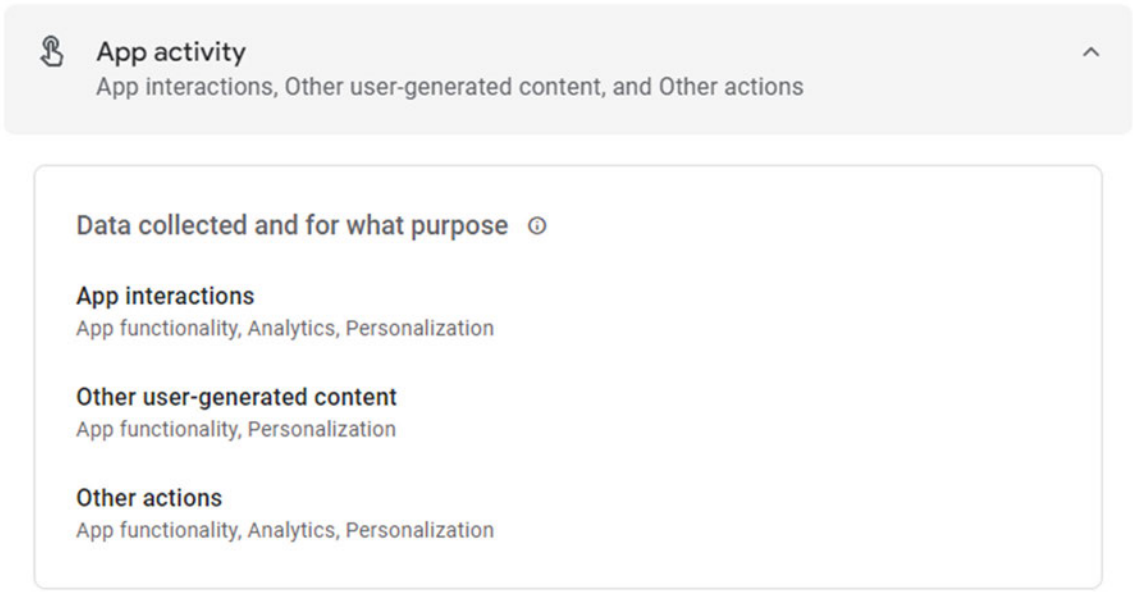


Figure 4. Screenshot from Career Karma Data Privacy page[12]

33. It also lists Device IDs will be collected for Analytics as well:

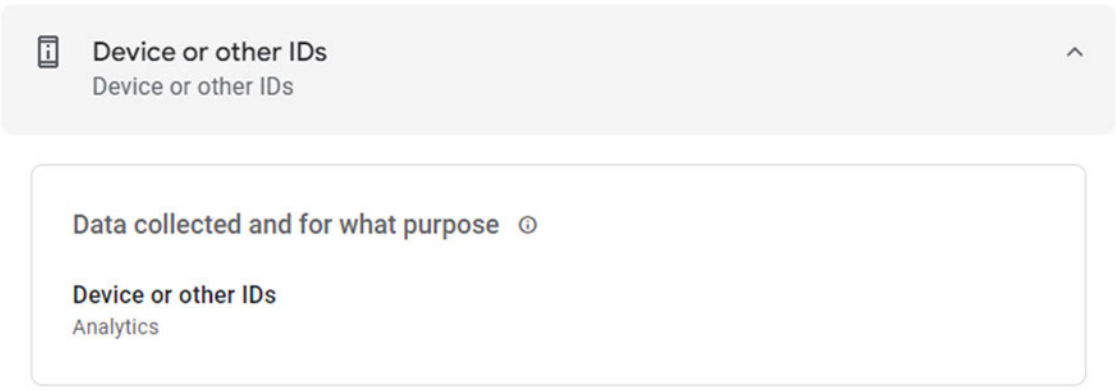


Figure 5. Screenshot from Career Karma Data Privacy page[13]

34. I have installed Career Karma on my Pixel 6a test device and after spending some time searching the app's menus, I do not see any option to disable Data Sharing or Data Collection for this app.

35. The Data Privacy page says, finally at the bottom, the collected data is theirs for good:

[12] "Career Karma," Google Play, available at https://play.google.com/store/apps/datasafety?id=com.careerkarma.chat.

[13] "Career Karma," Google Play, available at https://play.google.com/store/apps/datasafety?id=com.careerkarma.chat.

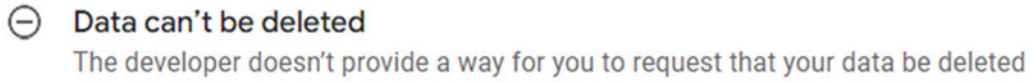


Figure 6. Screenshot from Career Karma Data Privacy page[14]

36. Back on the Career Karma main page, the top-listed review is 1-star and contains a complaint about the intrusive nature of the app:

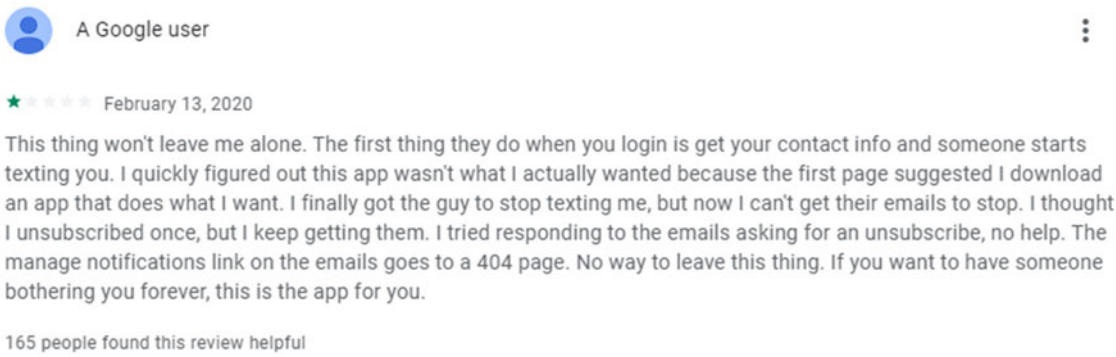


Figure 7. Screenshot from Career Karma Data App Information page[15]

37. This user submitted the above review on February 13, 2020, which is prior to the timeframe that Mr. Rodriguez was using the app according to the produced logs. Although the above is the experience of a single user (with 165 others finding the review "helpful"), it does suggest that perhaps this company takes an aggressive approach to using user data. And, as it turns out, they also violate the Google TOU forbidding the sending of personal information to Google's analytics servers. It is difficult to see how Mr. Hochman, in light of the above, could possibly cite the appearance of Mr. Rodriguez's personal information in a baseview log as evidence of wrongdoing by Google. Nor does Mr. Hochman cite to any evidence that Google ever used these pieces of information for any purpose. I am aware of no such evidence.

E. Information in Baseview Logs Related to Susan Harvey

38. Mr. Hochman also analyzes the appearance of personal data by another of the named plaintiffs: Susan Harvey.[16] Mr. Hochman cites similar data being disclosed for Ms. Harvey. Ms. Harvey has significantly fewer entries in the baseview logs compared to Mr. Rodriguez: whereas Mr. Rodriguez had 53,167 out of 123,302 entries, Ms. Harvey has just 11,870 entries.

---

[14] "Career Karma," Google Play, available at https://play.google.com/store/apps/datasafety?id=com.careerkarma.chat.

[15] "Career Karma," Google Play, available at https://play.google.com/store/apps/details?id=com.careerkarma.chat

[16] Hochman Report, ¶ 192.

39. As Mr. Hochman points out, Ms. Harvey's first and last name appears in the baseview production. In my analysis I found 383 instances of Ms. Harvey's name appearing in the produced baseview log, and in every instance the offending app was the Ulta app (com.ulta.Android), an app related to the large cosmetics chain. The Ulta app sent Ms. Harvey's name to Google's server as a *user_properties* entry:

…

Snippet 12.

Snippet 13.

40. Other user properties indicate that Ms. Harvey is an "Ultimate Rewards Credit Card" holder, she has opted into emails, her loyalty ID number with Ulta, that she is a "bronze member" (but not a "platinum member") and that she has been a member since July 3, 2021. Also stored as a *user_properties* entry is her zip code (another piece of information Mr. Hochman lists in his report):


```
{
    "key": "zip",
    "value":
    {
        "value":
        {
            "string_value": "93638",
            "original_value_type": 1
        },
        "set_timestamp_usec": "1638899575469000"
    }
}
```


Snippet 14.

41. Each of these 383 entries from the Ulta app also contains Ms. Harvey's phone number, again as a *user_properties* entry:


```
{
    "key": "mobile",
    "value":
    {
        "value":
        {
            "string_value": "[redacted]",
            "original_value_type": 1
        },
        "set_timestamp_usec": "1638899575469000"
    }
},
```


Snippet 15.

42. Ulta's 383 log entries constitute 3.2% of the 11,870 entries attributable to Ms. Harvey based on her ADID.

43. Unlike some of the apps discussed above for Mr. Rodriguez, it appears that the Ulta app includes this information in **every** event record sent to Google's servers.

44. Mr. Hochman lists other information included in log entries for Ms. Harvey such as the device model number being used, Android version number, latitude/longitude, etc. I have described above why these data do not describe any particular individual and do not constitute personal information.

45. The Ulta app is very popular: the Google Play page for this app lists over 5 million downloads. Like the other misbehaving apps above, the Ulta app has a Data Privacy page informing its users that a wide variety of information is collected and shared with other companies and organizations.

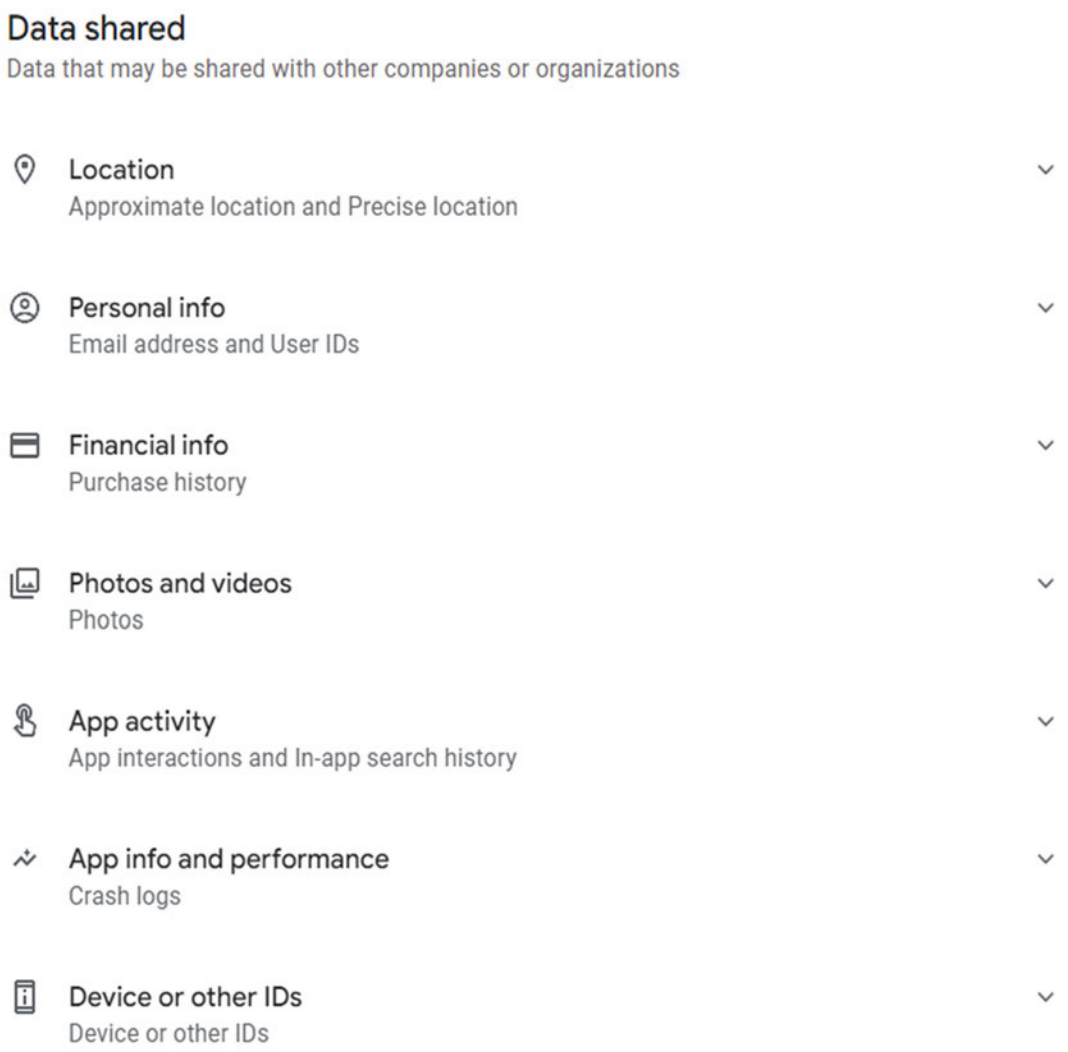


Figure 8. Screenshot from Ulta's Data Privacy page[17]

46. In every case, clicking on and expanding each category above, the app discloses that the shared information may be shared for Analytics purposes. In other words, the app developer is stating that the sharing of information such as name, phone number, location, etc., is for the benefit of Ulta itself in using Analytics to better personalize, optimize, advertise, etc., its services. (Once again, Google's analytics services do not permit many of these kinds of data to be sent to it.)

47. The Ulta app further discloses that "App Activity" may also be used for analytics purposes:

[17] "Ulta Beauty," Google Play, available at https://play.google.com/store/apps/datasafety?id=com.ulta.

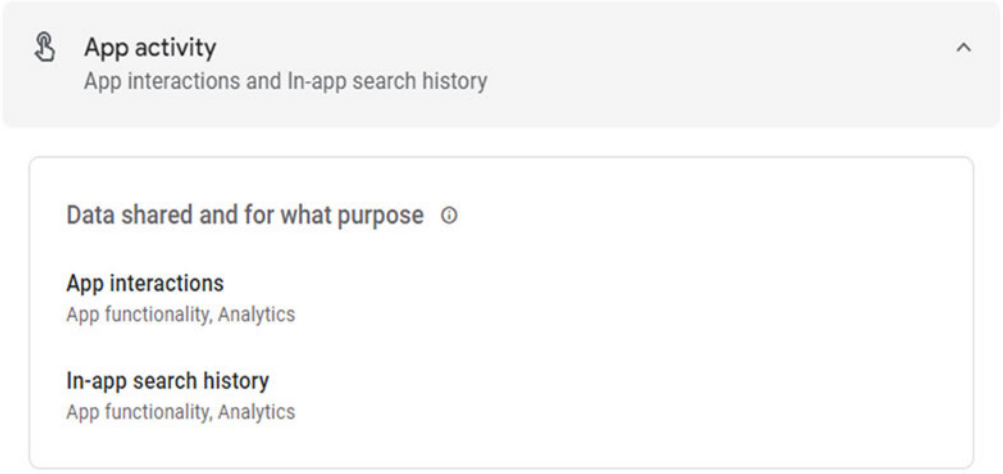


Figure 9. Screenshot from Ulta's Data Privacy page[18]

F. Conclusion

48. My analysis above, based on the same 766 and 767 baseview productions from Google that Mr. Hochman used, shows that in every instance cited by Mr. Hochman (and in other instances that I identified in my own analysis), any personal information logged by Google was sent by an app via custom entries in violation of Google's expressly stated policy forbidding such actions. Mr. Hochman in his report appears not to have performed this analysis himself and instead formed his opinions based on the mere presence of personal information in the baseview logs.

49. Given that Google proscribes sending personal information to its analytics servers and given the fact that the 7 apps listed above in this appendix do so in spite of Google's policy, it is my opinion that Google cannot be responsible, at a technical level, for the appearance of these types of information in its logs. Nor is there any evidence of which I am aware that Google ever used those pieces of information for any purpose.

50. To the extent that Mr. Hochman believes that Google should be held accountable for the actions of developers who violate Google's privacy policies, I disagree.

[18] "Ulta Beauty," Google Play, available at https://play.google.com/store/apps/datasafety?id=com.ulta.

UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA

ANIBAL RODRIGUEZ, SAL CATALDO, JULIAN SANTIAGO, and SUSAN LYNN HARVEY, individually and on behalf of all other similarly situated, Plaintiffs, v. GOOGLE LLC, Defendant.	No. 3:20-cv-04688-RS

REBUTTAL EXPERT REPORT OF JOHN R. BLACK, PH.D.

May 31, 2023

Appendix X3

Third Party Analytics Providers

I. OTHER EVENT TRACKING AND ANALYTICS FRAMEWORKS

1. Mr. Hochman opines that without WAA-off or sWAA-off data, Google would not be able to serve advertisements and charge the advertisers, would not be able to track conversions, and would not be able to attribute conversions to events.[1] In other words, Mr. Hochman believes that it would not be possible for Google to perform the tracking of conversion and the attribution to events if not for the fact that developers select Google's analytics frameworks (i.e., GA4F and GMA analytics) over other options.

2. This opinion ignores the fact that there are other options. GA4F (Google Analytics for Firebase) and GMA analytics are but one option a mobile app developer has for collecting information from a mobile app. There are a host of other options available, oftentimes with free tiers like Google's offerings, that offer similar collection and attribution features. Some of these are better in many ways than Google's offerings, and some major companies (presumably because of these advantages) do opt for non-Google analytics frameworks.

3. In this appendix, I review a few of the more popular alternatives to Google's mobile analytics platforms.

A. Facebook SDK

4. Meta offers the Facebook SDK for free. The SDK offers an authorization platform allowing mobile users to log into Facebook as a way to authenticate themselves. The SDK also supports posting to Facebook from an app, advertising an app, and of course has support for app event measurement.

Figure 1. Features available with Facebook SDK for Android.[2]

5. To use the Facebook SDK, a developer would first create a Developer Account with Meta and register the app there, then generate a "client token" to be embedded in the app to be remitted to Facebook at runtime. The app developer then imports the SDK into the app's project, updates the relevant build scripts and adds the app id and client token to the manifest. The manifest also contains the needed permission for the app; in this case the app will need Network permissions (to send analytics data to Facebook) and, unless the developer opts out, Advertising ID Permission (as of Android 13). Finally, the app will need to be signed (or supply a self-signed certificate for testing purposes, as I have done for my testing).[3]

6. The Facebook SDK can track three types of events:

---

[1] Hochman Report, ¶¶ 271, 272, 280.

[2] "Facebook SDK for Android," Meta for Developers, https://developers.facebook.com/docs/android/.

[3] "Getting Started with the Facebook SDK for Android," Meta for Developers, https://developers.facebook.com/docs/android/getting-started/.

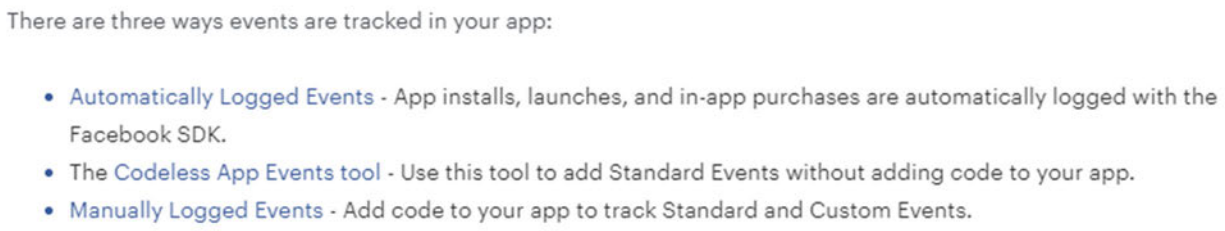


Figure 2. Three ways events are tracked using Facebook SDK.[4]

7. The first two types of events are automatically collected by the SDK and the last type, Manually Logged Events, requires the developer to add code to log specific events with parameters of the developer's choosing (this is similar to logEvent() in the GA4F SDK).

i. Automatically Logged Events with Facebook SDK

8. If the developer does not disable automatic event logging, the following events are automatically logged and collected by Facebook. Some of the automatically logged events collected by the Facebook SDK are shown below:

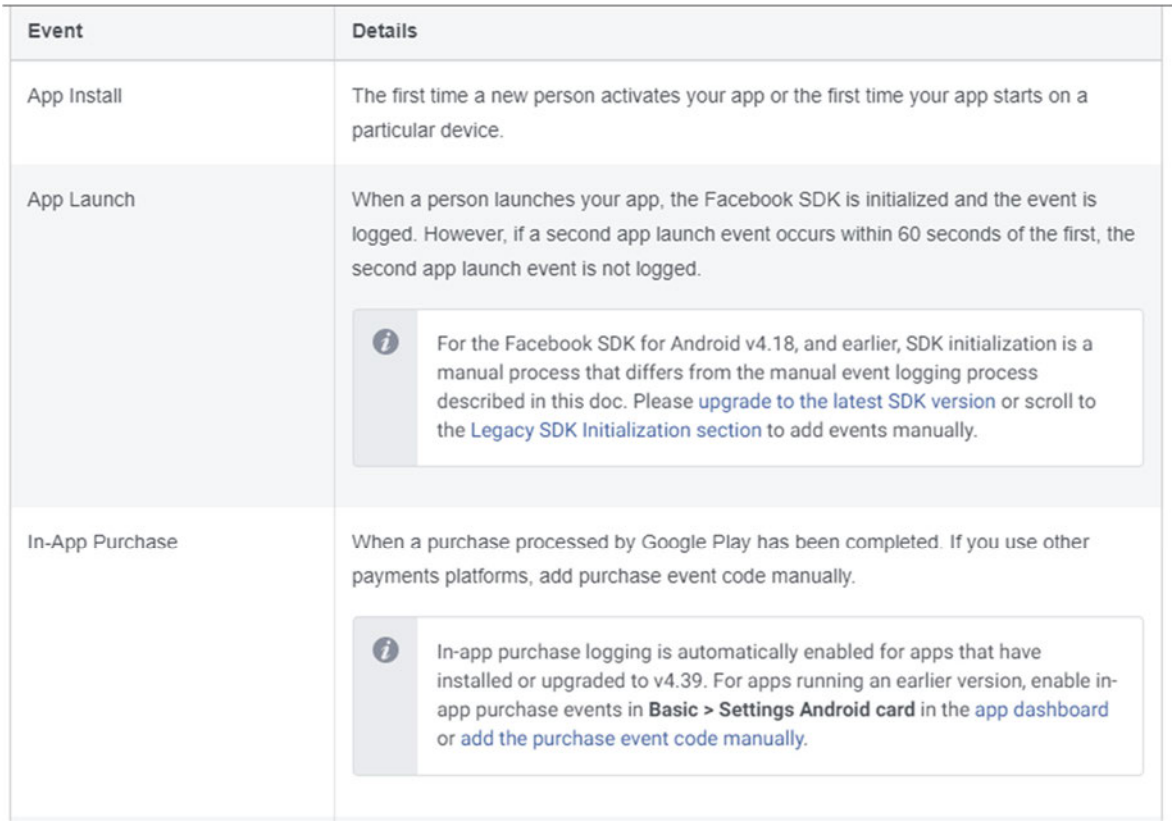


Figure 3. Automatically logged events.[5]

[4] "Get Started with App Events," Meta for Developers, https://developers facebook.com/docs/app-events/getting-started-app-events-android.

[5] "Get Started with App Events," Meta for Developers, https://developers facebook.com/docs/app-events/getting-started-app-events-android.

9. These events are analogous to the similarly-named automatically collected events in the GA4F SDK.

10. Codeless App Events are added through the Facebook Events Manager.[6] Events added here will automatically be collected by the associated app without the addition of logging calls in the source code. Although this allows non-developers (such as marketing personnel) to add events to an app without needing to write code, it is not as flexible or powerful as writing custom event code directly.[7]

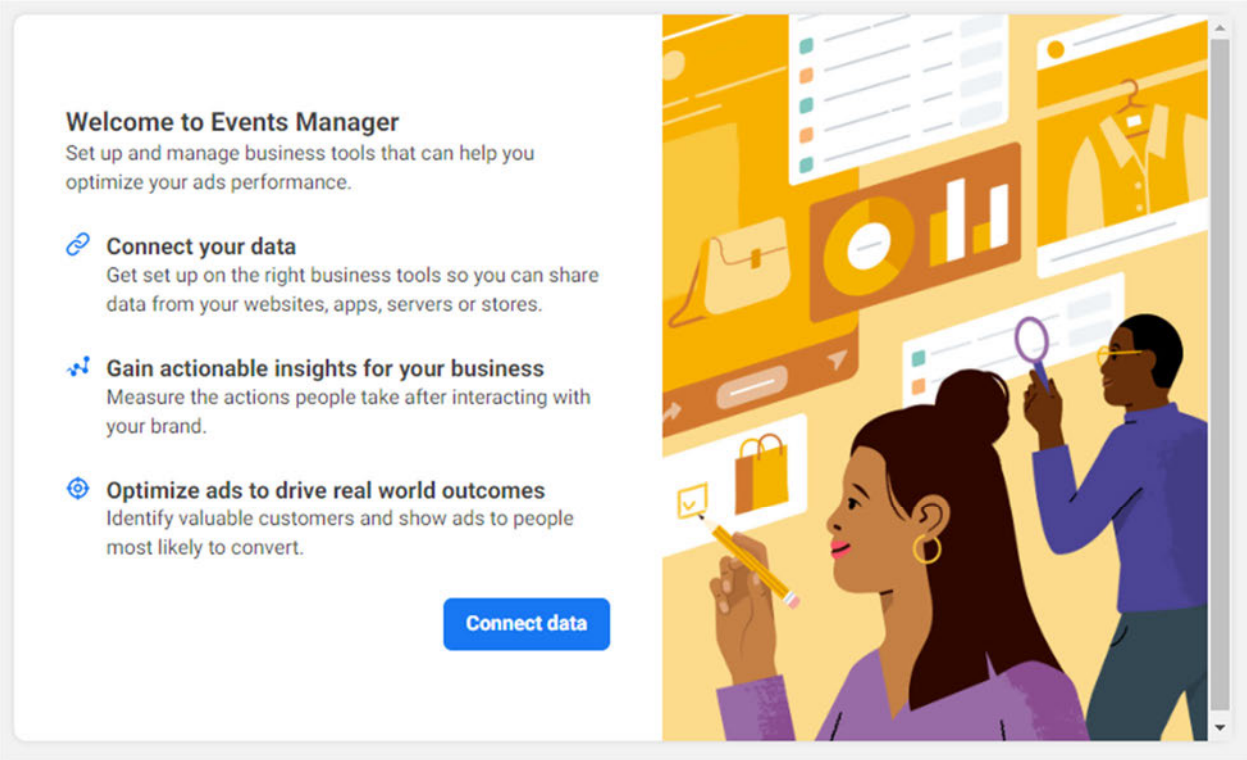


Figure 3. Facebook Events Manager.[8]

ii. Manually Logged Events

11. If a developer wishes to manually log events, they first create an event Logger object, and then use the logEvent() method to log events to the Facebook servers. For Android, the Standard Events available include the ability to specify the "level" of a user, app launch event, ad clicks, ad impressions, customer payments, item added to cart, item added to wish list, user completed registration, user completed a tutorial, user-initiated checkout, purchase completed, and many other event types.

12. In particular, Facebook supports an event recording contact information:

---

[6] *See* "Events Manager Overview," Facebook, https://www facebook.com/events_manager2/overview.

[7] *See* "Introducing Codeless App Events Setup as Part of New Facebook SDK," Meta, https://developers.facebook.com/blog/post/2018/06/25/codeless-app-events-setup-facebook-sdk/.

[8] "Events Manager Overview," Facebook, https://www.facebook.com/events_manager2/overview.

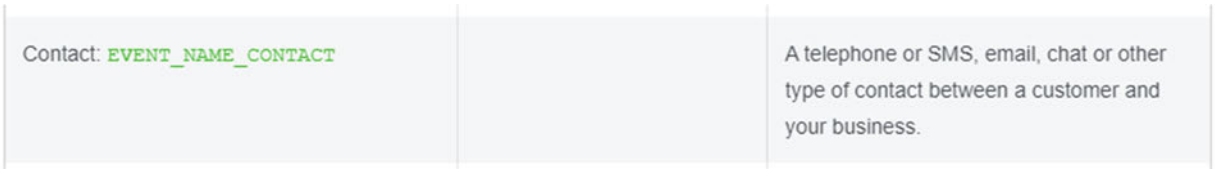


Figure 4. Event to record contact information.[9]

13. The event types listed above usually come with associated parameters to provide the information indicated by the event type. The Facebook SDK lists a number of Standard Event Parameters to be included with manually logged events. These include a generic string type called EVENT_PARAM_DESCRIPTION that presumably describes the event, and a generic EVENT_PARAM_CONTENT that contains JSON with arbitrary content. This is analogous to the event_params sent with logEvents() in the GA4F SDK.

14. Meta provides various tools to view event and ads data via a GUI. The Meta Business Suite provides an integrated site for managing a business's needs across Facebook and Instagram and provides analytics tools for businesses.[10] The Facebook Events Manager, discussed above, also provides data visualization tools for ad campaigns and event tracking.

15. Although the screenshots and API descriptions above were for the Android platform, the Facebook SDK supports iOS. Similar to the GA4F SDK, iOS support is limited by the restrictions introduced with iOS 14 as described in my main report.

B. AppsFlyer

16. AppsFlyer is a 3rd party cloud-based mobile attribution and analytics platform supporting a wide variety of attribution techniques and conversion tracking.[11] The platform is more comprehensive than the Facebook SDK: it attempts to map the full customer journey (i.e., the customer's actions from first impressions to a conversion) and has a rich set of attribution tools.

17. AppsFlyer touts its high priority on privacy:

[9] "Facebook App Events Reference," Meta for Developers, https://developers.facebook.com/docs/app-events/reference/.

[10] "Let's get started with business tools from Meta," Meta, https://business.facebook.com/.

[11] *See* "Make good choices," AppsFlyer, https://www.appsflyer.com/.

Figure 5. Privacy at AppsFlyer.[12]

18. The company states they go "beyond the GDPR and CCPA" by adhering to the restrictions in those laws but also "helping customers ensure their own compliance as well."[13]

19. That said, the AppsFlyer privacy policy does include the collection of personal information:

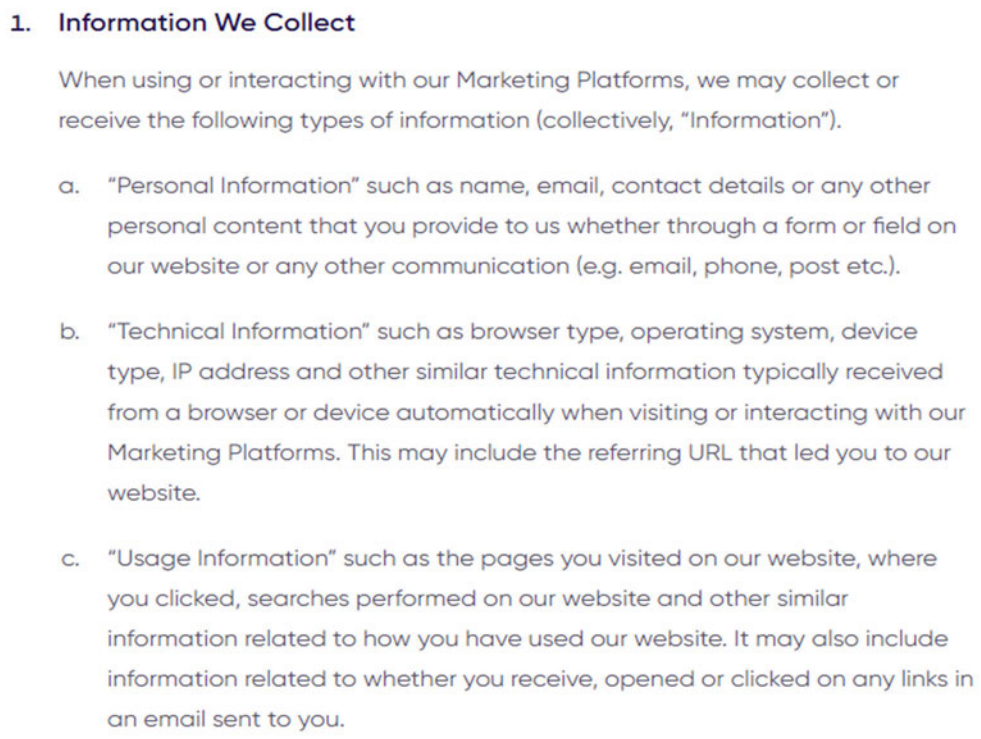


Figure 6. AppsFlyer Privacy Policy.[14]

12 "Privacy at AppsFlyer," AppsFlyer, https://www.appsflyer.com/trust/privacy/.
13 "Privacy at AppsFlyer," AppsFlyer, https://www.appsflyer.com/trust/privacy/.
14 "Website Privacy Policy," AppsFlyer, https://www.appsflyer.com/legal/privacy-policy/.

20. The privacy policy goes on to state that "We understand that certain Technical information or Usage Information may, either alone or when combined with other data, be deemed personal data under various laws and jurisdictions and we are committed to treating such data in compliance with applicable laws."[15] In other words, their policy is in line with what Google and others do.

i. AppsFlyer SDK

21. Similar to the configuration for GA4F and Facebook, the first step to integrate AppsFlyer into a developer's app is to make an account with AppsFlyer, register your app with the service, and obtain a client key. The AppsFlyer SDK is then integrated with the app's code, the key is added to the manifest and the build parameters are changed to include the SDK.[16]

22. For event generation, the developer decides on which category of events the app will track. AppsFlyer has a very large list of supported events, segregated by category:

Figure 7. AppsFlyer's recommended event by business vertical.[17]

[15] "Website Privacy Policy," AppsFlyer, https://www.appsflyer.com/legal/privacy-policy/.

[16] Once again, I will refer to the Android materials, but there are analogous steps undertaken for the iOS SDK. The steps for Android are listed at https://dev.appsflyer.com/hc/docs/install-android-sdk.

[17] "Rich in-app events—Overview," AppsFlyer Help Center, https://support.appsflyer.com/hc/en-us/articles/115005544169-Rich-in-app-events-guide#recommended-events-by-business-vertical.

23. Once the vertical is selected, the developer uses the Event Generator to define the event; for example one can add the "add_to_cart" event beginning from this screen:

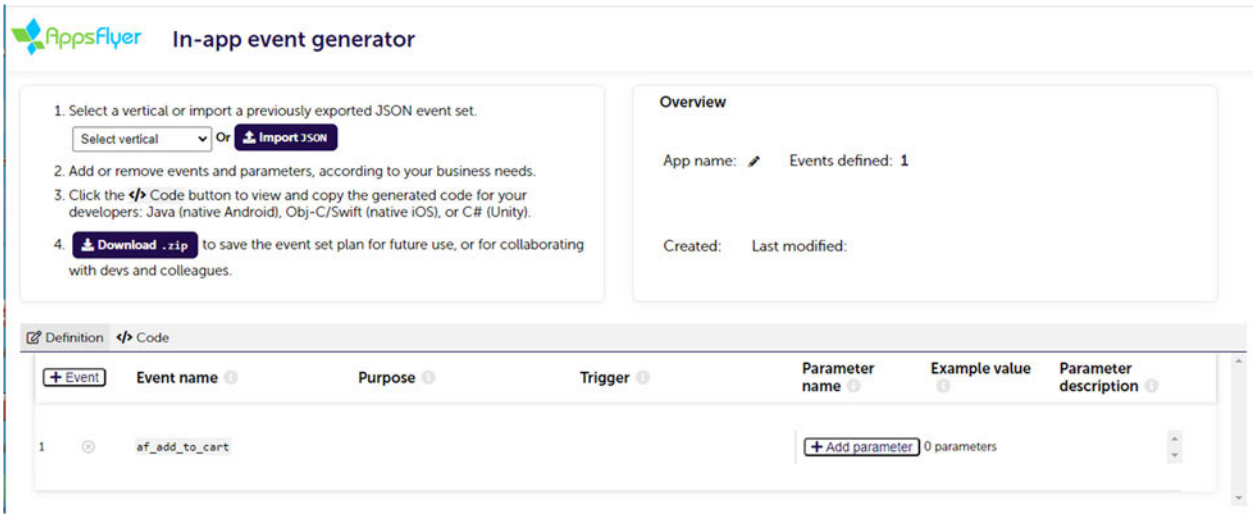


Figure 8. AppsFlyer in-app event generator.[18]

24. Once the event is defined, the developer can click on the "</> Code" button that will display the appropriate code that should be integrated into the app to generated the given event.

25. Like GA4F and Facebook, AppsFlyer SDK allows custom events as well.

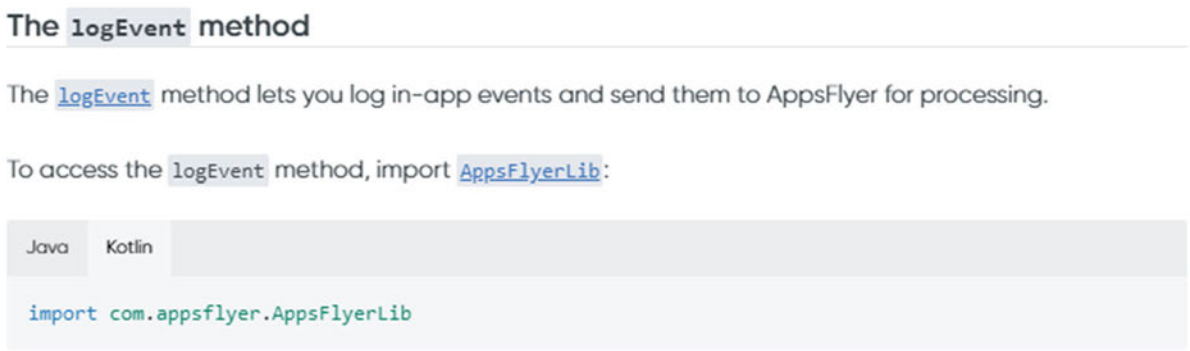


Figure 9. AppsFlyer in-app events for Android.[19]

26. Android event names are listed on the same page; a partial list includes these:

[18] "In-app event generator," AppsFlyer, https://evgen.appsflyer.com/.
[19] "In-app events," AppsFlyer, https://dev.appsflyer.com/hc/docs/in-app-events-android.

Event name	Android constant name
"af_level_achieved"	AFInAppEventType.LEVEL_ACHIEVED
"af_add_payment_info"	AFInAppEventType.ADD_PAYMENT_INFO
"af_add_to_cart"	AFInAppEventType.ADD_TO_CART
"af_add_to_wishlist"	AFInAppEventType.ADD_TO_WISHLIST
"af_complete_registration"	AFInAppEventType.COMPLETE_REGISTRATION
"af_tutorial_completion"	AFInAppEventType.TUTORIAL_COMPLETION
"af_initiated_checkout"	AFInAppEventType.INITIATED_CHECKOUT
"af_purchase"	AFInAppEventType.PURCHASE
"af_rate"	AFInAppEventType.RATE

Figure 10. AppsFlyer in-app events for Android.[20]

27. And the event parameters can hold whatever the developer desires, similar to the event_params variable in GA4F.

28. AppsFlyer has a marketing analytics tool just as Facebook and Google do, but its main selling point is its attribution model. This model attempts to map the customer's journey from first impression to acquisition (e.g., app install).

[20] "In-app events," AppsFlyer, https://dev.appsflyer.com/hc/docs/in-app-events-android.

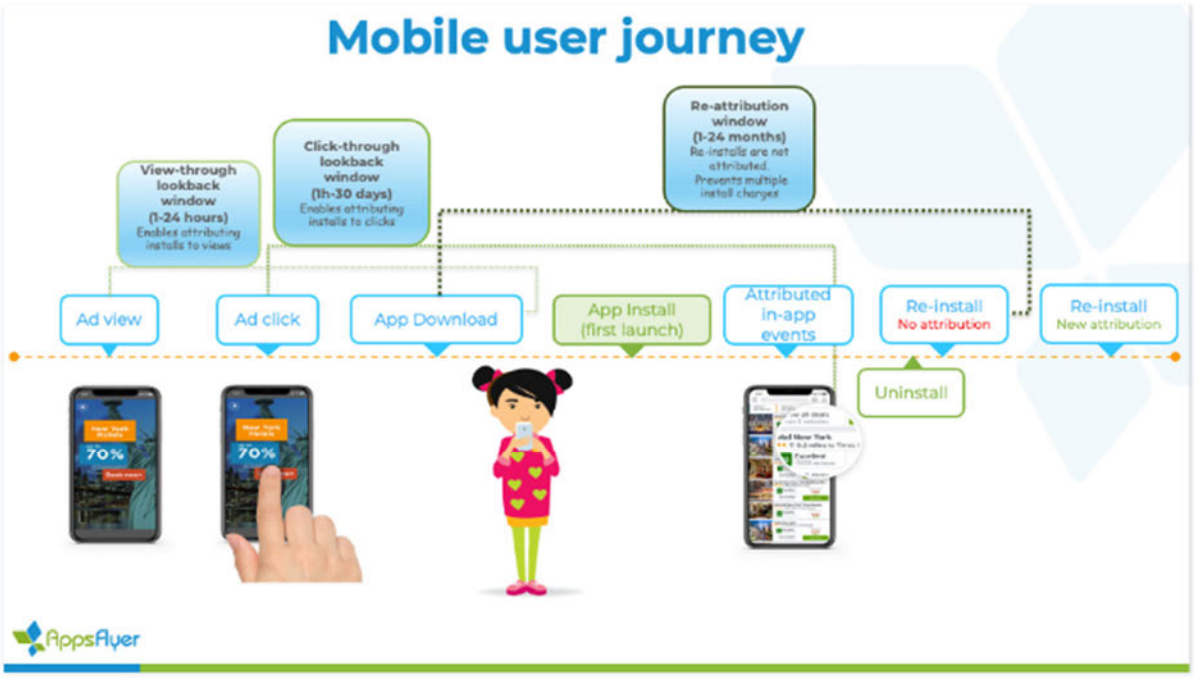


Figure 11. AppsFlyer attribution model.[21]

29. Attribution is attempting to determine why a user installed an app or performed other post-installation acts like re-engagement.[22] Understanding how a company is acquiring users for its mobile app is of course important to increasing the size of its customer base. Its comprehensive attribution model is often what sets AppsFlyer apart from its competitors (along with its ability to integrate with Android, iOS and Facebook).

30. AppsFlyer touts several recognizable brands who use its platform:

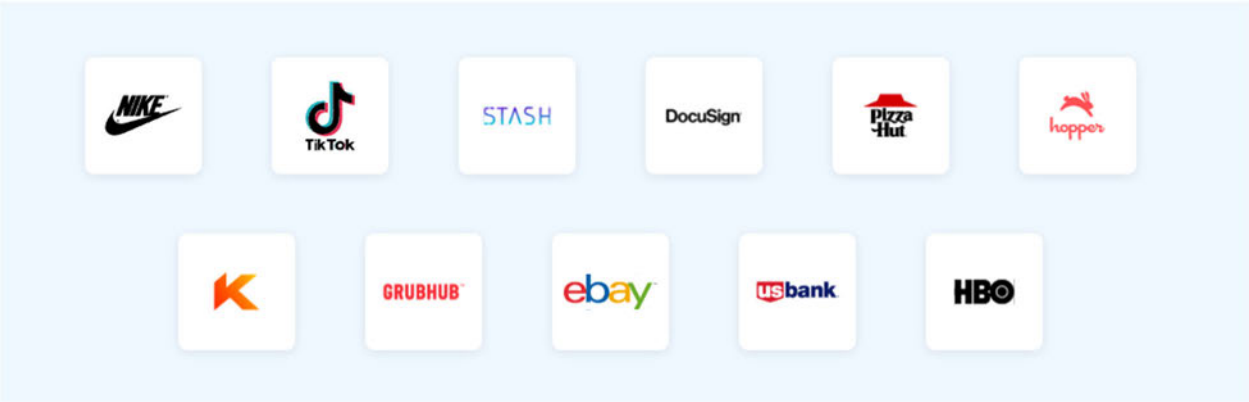


Figure 12. AppsFlyer customers.[23]

[21] "AppsFlyer attribution model," AppsFlyer Help Center, https://support.appsflyer.com/hc/en-us/articles/207447053-AppsFlyer-attribution-model.

[22] "Attribution modeling," AppsFlyer, https://www.appsflyer.com/glossary/attribution-modeling/.

[23] "Trusted by leading brands, around the world," AppsFlyer, https://www.appsflyer.com/customers/.

C. Flurry Analytics

31. Flurry is another major player in the mobile apps analytics space. Flurry was acquired by Yahoo in 2014 and is sometimes referred to as "Flurry Yahoo" though often it is marketed as simply "Flurry."[24] Flurry's website touts itself as "The World's Most Adopted App Analytics" and claims they have "helped hundreds of thousands of companies build millions of apps for billions of customers."[25]

32. The steps involved in integrating Flurry into an Android app are very similar to the steps shown above for the other analytics platforms: sign up as a developer (with Yahoo), register the app with Flurry, get an API key, install the Flurry SDK, update Gradle build script, and update the manifest.[26]

i. Standard Events

33. Flurry supports a long list of built-in standard events, many of which resemble the standard event types from other platforms in this report. For example, registration events are supported:

Registration	Login	Log this event when a user login on the App	userId, method
Registration	Logout	Log this event when a user logout of the App	userId, method
Registration	UserRegistered	Log the event when a user registers (signup). Helps capture the method used to sign-up (signup with google/apple or email address)	userId, method

Figure 13. Flurry registration events.[27]

[24] *See* "Yahoo! Acquires Flurry: Inexpensive Audience Acquisition For Yahoo!," Forbes, https://www forbes.com/sites/forrester/2014/07/22/yahoo-acquires-flurry-inexpensive-audience-acquisition-for-yahoo/?sh=5585e22ffce6.

[25] *See* "The World's Most Adopted App Analytics," Flurry, https://www.flurry.com/.

[26] *See* "Integrate Flurry SDK for Android," Yahoo Developer Network, https://developer.yahoo.com/flurry/docs/integrateflurry/android/.

[27] "Standard Event with Flurry Analytics Android," Yahoo Developer Network, https://developer.yahoo.com/flurry/docs/analytics/standard_events/Android/.

34. Standard events can be logged alongside event parameters in the FlurryEvent.Params class; some of the supported event parameters include these:

contentName	string
contentType	string
contentId	string
creditName	string
creditType	string

Figure 14. Flurry event parameters.[28]

35. Standard events are logged via the logEvent() method along with event parameters:

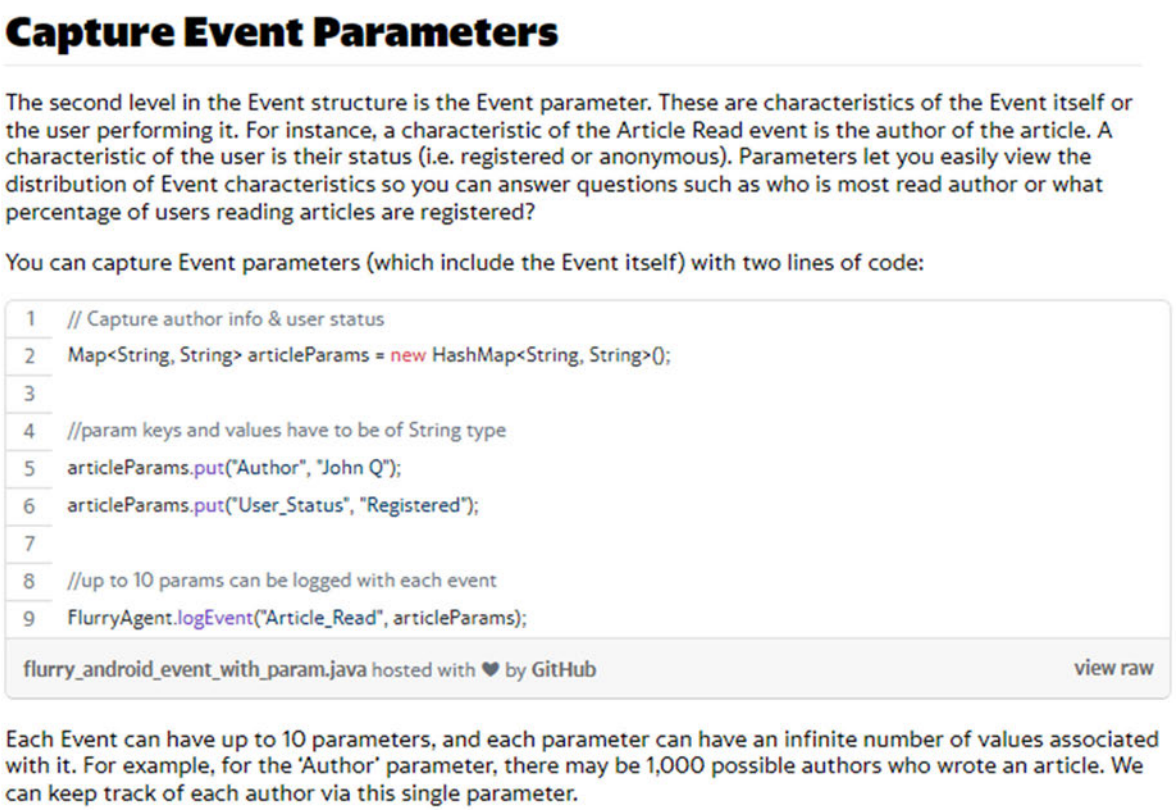
```
1  FlurryEvent.Params params = new FlurryEvent.Params()
2          .putDouble (FlurryEvent.Param.TOTAL_AMOUNT, 34.99)
3          .putBoolean(FlurryEvent.Param.SUCCESS, true)
4          .putString (FlurryEvent.Param.ITEM_NAME, "book 1")
5          .putString ("note", "This is an awesome book to purchase !!!");
6      FlurryAgent.logEvent(FlurryEvent.PURCHASED, params);
```

Figure 15. Example of logging a purchase event using the new standard event protocol with Flurry SDK.[29]

ii. Custom Events

36. Like Firebase, Facebook and AppsFlyer, Flurry offers the developer the ability to create custom events logging just about anything. Flurry limits the number of unique event names up to 500 per app.[30] Event parameters are created as HashMap objects and then passed along with the event name to FlurryAgent.logEvent with the event name and parameters. An example of an event "article read" is as follows:

[28] "Standard Event with Flurry Analytics Android," Yahoo Developer Network, https://developer.yahoo.com/flurry/docs/analytics/standard_events/Android/.
[29] "Standard Event with Flurry Analytics Android," Yahoo Developer Network, https://developer.yahoo.com/flurry/docs/analytics/standard_events/Android/.
[30] "Custom Events with Flurry Analytics for Android," Yahoo Developer Network, https://developer.yahoo.com/flurry/docs/analytics/gettingstarted/events/android/.



Capture Event Parameters

The second level in the Event structure is the Event parameter. These are characteristics of the Event itself or the user performing it. For instance, a characteristic of the Article Read event is the author of the article. A characteristic of the user is their status (i.e. registered or anonymous). Parameters let you easily view the distribution of Event characteristics so you can answer questions such as who is most read author or what percentage of users reading articles are registered?

You can capture Event parameters (which include the Event itself) with two lines of code:

```
1  // Capture author info & user status
2  Map<String, String> articleParams = new HashMap<String, String>();
3
4  //param keys and values have to be of String type
5  articleParams.put("Author", "John Q");
6  articleParams.put("User_Status", "Registered");
7
8  //up to 10 params can be logged with each event
9  FlurryAgent.logEvent("Article_Read", articleParams);
```

flurry_android_event_with_param.java hosted with ♥ by GitHub view raw

Each Event can have up to 10 parameters, and each parameter can have an infinite number of values associated with it. For example, for the 'Author' parameter, there may be 1,000 possible authors who wrote an article. We can keep track of each author via this single parameter.

Figure 15. Example of event parameter with Flurry SDK.[31]

37. HashMaps are a general structure in Android and therefore can contain virtually any data the developer desires.[32] Once logged to Flurry's backend, data visualization tools can be used to analyze data being sent by a Flurry-instrumented app.

iii. Flurry Explorer

38. The Flurry backend visualization instrument is called "Explorer."[33] Explorer allows users to track events as well as measure user paths, user journeys, "funnels" (their name for conversion tracking), retention and other measures. For example, the Funnel view within Explorer looks similar to other analytics visualization displays:

[31] "Custom Events with Flurry Analytics for Android," Yahoo Developer Network, https://developer.yahoo.com/flurry/docs/analytics/gettingstarted/events/android/.

[32] "HashMap," Google for Developers, https://developer.android.com/reference/java/util/HashMap.

[33] *See* "Explorer Overview," Yahoo Developer Network, https://developer.yahoo.com/flurry/docs/analytics/explorer/getstarted/. *See also,* "Get Started with Flurry Explorer," Yahoo Developer Network, https://developer.yahoo.com/flurry/docs/analytics/explorer/building-queries/.

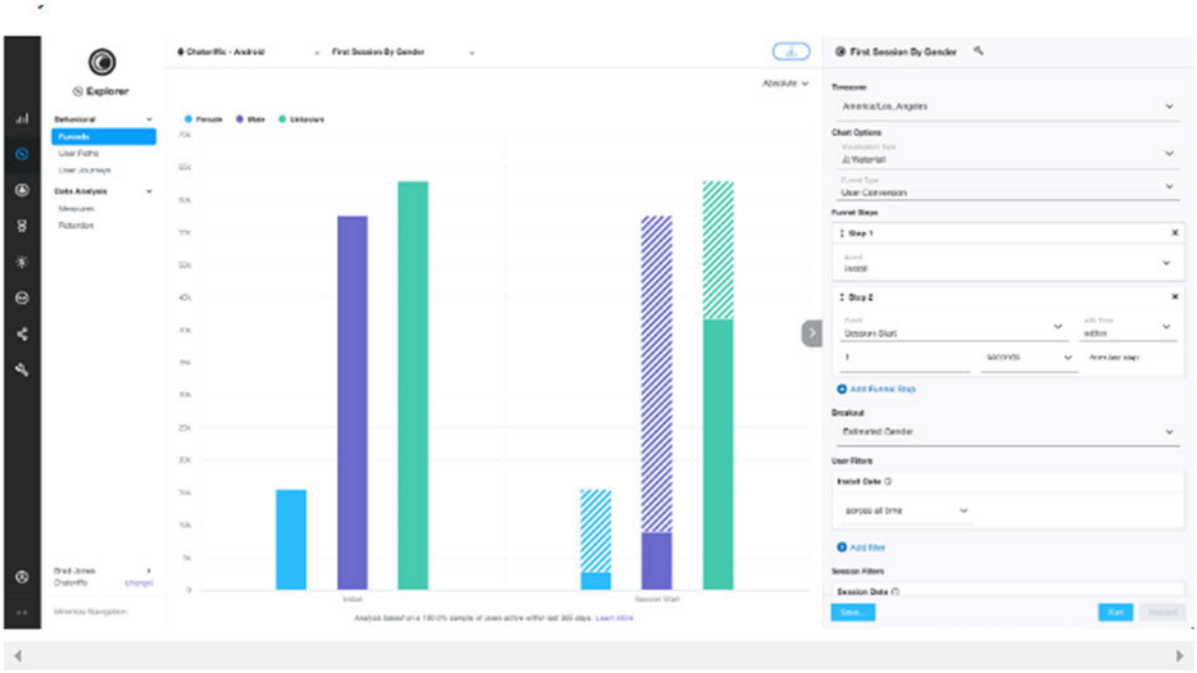


Figure 16. Example of Funnel view within Flurry Explorer.[34]

39. Flurry touts a number of well-known major companies as customers.

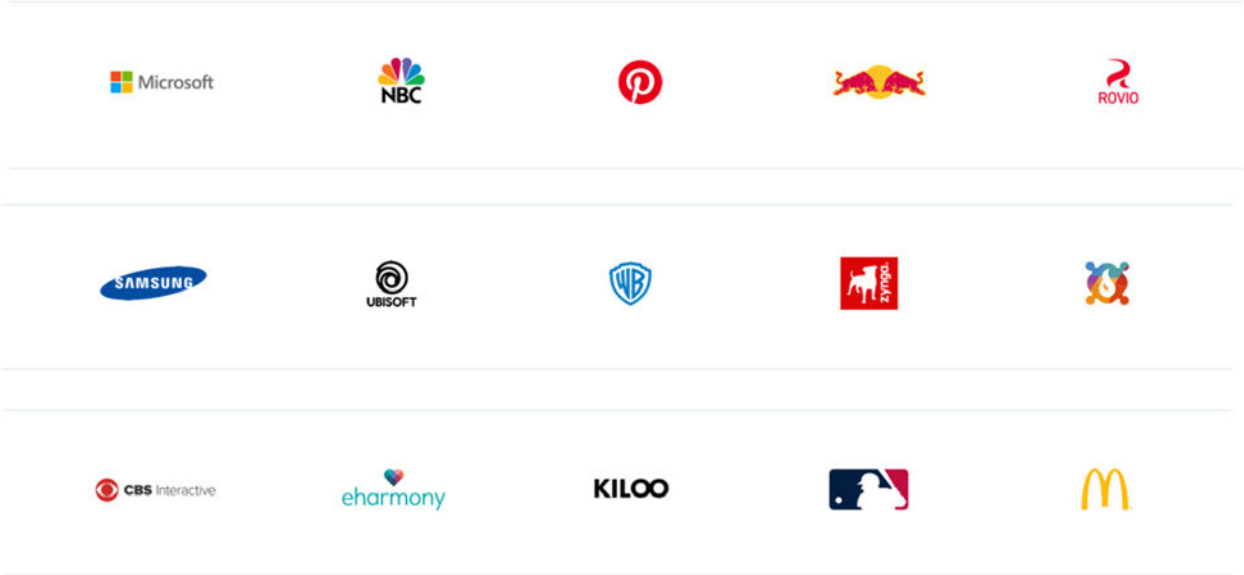


Figure 17. Flurry customers.[35]

[34] "Funnels & Conversion Funnel Analysis," Yahoo Developer Network, https://developer.yahoo.com/flurry/docs/analytics/explorer/funnels/.

[35] "The World's Most Adopted App Analytics," Flurry, https://www flurry.com/.

II. OTHER ANALYTICS PLATFORMS

40. Although I have reviewed a few platforms at a high level in the preceding sections, there are a number of other options available to developers looking for alternatives to GA4F. For example, searching a web search for "best mobile app analytics android" lists these 23 platforms (20 excluding Google):

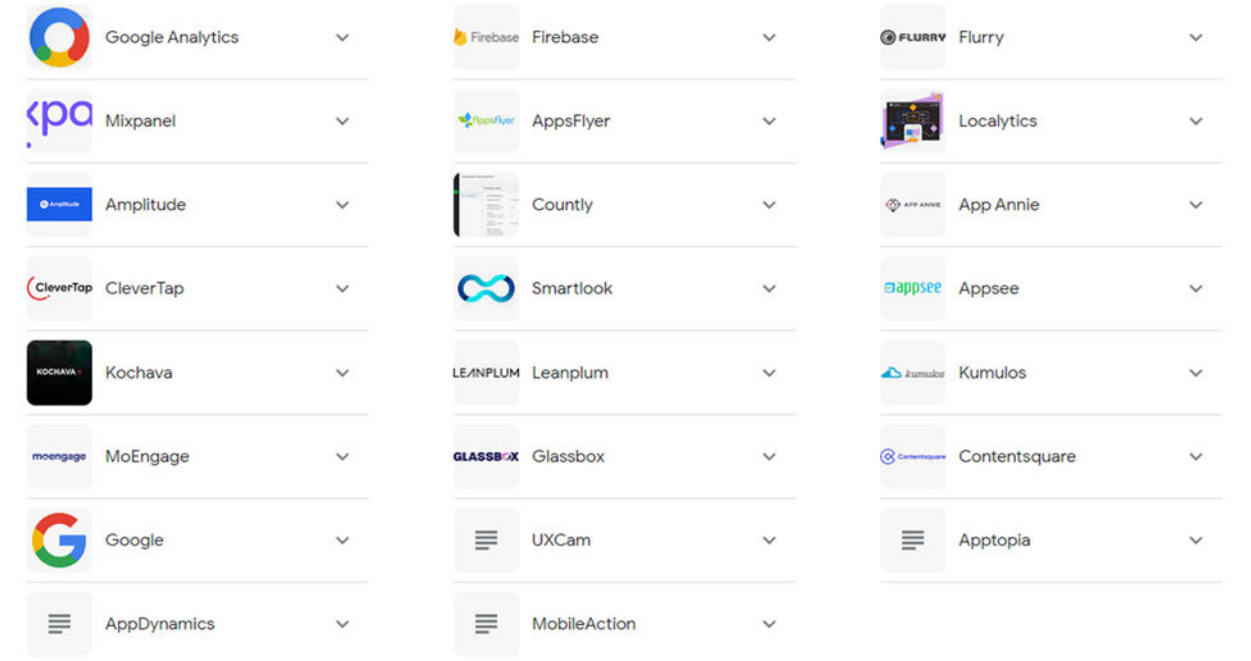


Figure 18. Web search results for "best mobile app analytics android".[36]

41. Google, Google Analytics and Firebase are part of Google. Flurry is owned by Yahoo. AppDynamics is now part of Cisco. Amplitude went public in 2014 with a market cap over $7 billion USD, and claims over 700 employees and 1,900 customers including 26 of the Fortune 100; on their website they claim to be "#1 in product analytics."[37]

[36] "best mobile app analytics android", Google, https://www.google.com/search?q=best+mobile+app+analytics+android&rlz=1C1GCEB_enUS1010US1010&oq=best+mobile+app+analytics+android&aqs=chrome..69i57j0i22i30l2j0i390i650l4.538j0j7&sourceid=chrome&ie=UTF-8&bshm=ncc/1.

[37] "We live in a digital-first world," Amplitude, https://amplitude.com/company.